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DEVOTED TO THE INTERESTS OF

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AND

GENERAL SCIENCE.

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[OFFICIAL NOTICE.]

January Meeting, Guild of Gas Managers.

OFFICE OF THE SECRETARY, Dec. 31, 1897.

The January meeting of the Guild of Gas Managers will be held in Young's Hotel, Boston, Mass., at noon of Saturday, next.

A. K. QUINN, Secretary.

BRIEFLY TOLD.

IS THE SAVING WORTH THE DIFFERENCE?—The main motive power of trading is confidence, and the decreasing of confidence usually results in a narrowing of fair commercial relations between those who buy and sell. Gas companies sell and gas consumers buy, and much of the trouble that exists between the sellers and buyers of the product under consideration is traceable to the unfortunate thought that the buyers are not very firm believers in the accuracy of the meters through which the supply of the sellers is measured. Following out that thought, the law makers have, to the protection of the buyers, established legal conditions under which gas users may have, at the expense of the gas makers, complete proof that the gas meters on their premises are marking up that which passes through them, and marking up no less—for when a gas meter, as a result of such test, was found to be slow, no record exists that the consumer turned over to the company any sum compensating it for the gas which he used, but for which the company was not paid. The regulations by law for testing gas meters are, from this point of view (and it is the only point from which they may be viewed), all in favor of the consumer, and it is well that they are, since the seller has no right of appeal to a higher authority, nor does the gas seller care to appeal, since he knows that the instrument which stands between him and his customer, under the action of sensible placing and reading, is as accurate as a machine may be. With this knowledge well before us, always remembering that the consumer knows the gas meter is not made by the gas company that serves him, it would look to be poor policy that any gas company should engage on its own account in either the manufacture or repair of the vessels that measure for both company and consumer. Perhaps it might be well to amend the statement that *any* gas company should not engage in the repair of its meters, but only to the point of allowing that gas companies located so far from any regularly operated meter manufacturing shop, that the transportation charges would eat up the difference between an old meter and a new one, would be excepted. In Mr. Brackenridge's article (JOURNAL, dated December 6th last), entitled "X-Rays on the Gas Bill," the author makes many very strong pleas for the gas companies in support of their fair dealing with their customers, not the least cogent and potent of which pleas appears in the paragraph containing the lines: "* * * And when we repeat that the gas is registered by a meter manufactured, not by the gas company, but by independent concerns, and tested by officials appointed by the State, there remains no possible way in which the company could be otherwise than square and fair in its dealings with the people." Suppose, however, that the people knew that the company was either making or repairing its own meters. Would the people believe, as the company would, or as we would, that the meters, old or new, were as accurate, no matter how much official testing the vessels were put to, or how many badges were pinned to them, as if the meters had been made or repaired by a concern whose remaining in business would rest on the fact that its product was well and regularly made, with the gas company as its severest critic? A well put together paragraph on this subject will be found in our current "Item Columns," under the signature of "Veritas," and it is his mention, together with Mr. Brackenridge's lines, that prompted the present reference to the good

or bad policy of gas companies, under normal conditions of pro pinquity to gas meter works, engaging in the manufacture or repair of gas meters on their own account. To name an instance as to the doubtfulness of the practice, we might and do quote the Consolidated Gas Company, of New York, which has gone into the business of at least *repairing* meters on an extensive scale. The Consolidated Gas Company does quite a large trading in its legitimate sphere, and with that business it should rest content, permitting others to live who have less claim of permanent interest in the goods that are sold than is the interest of those who buy them. To follow the practice of the Consolidated Com pany to its final conclusion might mean that every gas consumer should assume the right to make his own meter, the consumer admitting, too, that the State should have the right to test the meter when ever the Company feared that the meter was not performing its full duty. The whole matter comes down to a reply to the question which introduces this paragraph, "Is the Saving Worth the Difference?" and our reply is that it is not.

THE POWER OF ACETYLENE.—The latest illustration of the power fulness of acetylene gas, undergoing compression, was most unfortunately shown, on the morning of December 24th, in Jersey City, New Jersey, when the works of the United States Acetylene Company were demolished. The explosion not only wrecked the plant, but caused the death of two of the Company's employees, one of whom (Max Grim) was the Superintendent of the factory. This deplorable accident, following as it did the fatal affair (December 16) in Wilmington, Del., as noted in the JOURNAL for last week, has already resulted in a change of belief and practice on the part of the insurance men of New Jersey respecting acetylene gas and its use, which puts them on a risk basis somewhat allied to the basis which has heretofore existed in that regard in the States of Connecticut, New York and Pennsylvania.

NOTES.—The Gas Commission of New York city received bids for the public lighting, on the afternoon of December 29th. The bids were referred for tabulation.——At the annual meeting of the stockholders in the Ilion and Mohawk (N. Y.) Gas Company, the following officers were chosen: Directors, Thomas Ringwood, John Hoefler, John V. Schmidt, M. J. Richards, A. E. Brooks, A. N. Russell, James Conk ling, W. W. Benton and Ralph D. LeRoy; President, Thomas Ring wood; Vice-President, John Hoefler; Treasurer, John V. Schmidt; Secretary, Ralph D. LeRoy; Manager, John A. Giblin.——The death of Mr. William Raymond Lee Ward occurred in this city on the afternoon of December 23d. Deceased, who was born in Salem, Mass., August 26th, 1811, was one of the organizers of the Beverly (Mass.) Gas Light Company.——According to the report of the gas trustees of Hamilton, Ohio, the results achieved by the operation of the municipal gas and electric light works for November last were as follows: Gas plant, earnings, $3,178.09; expenses, $1,590.25. Electric plant, earnings, $2,272.58; expenses, $1,013.——On December 27th the Hartford City (Conn.) Gas Light Company declared a semi-annual dividend of 4 per cent., payable on or after to-day.——The following self-explanatory letter was forwarded to Chief Park, on December 27th, by Mr. Thomas T. Thompson, Director of Public Works, Philadelphia: "Dear Sir—The Philadelphia gas works having been leased to the United Gas Improvement Company, as authorized by ordinance of Councils, approved November 12th, 1897, and Councils having made no appropriation to continue any of the employees of the Bureau of Gas beyond December 31, 1897, your services as Chief of the Bureau of Gas and as an employee of the city will expire on that day. In severing our official relation I desire to testify to your great worth as a public official. Dur ing your many years of service, both as Chief Engineer of the Philadelphia gas works, and as Chief of the Bureau of Gas, you have proved yourself to be a most capable and faithful official. I have always found you an efficient and painstaking officer, earnest and ambitious in your desire to serve the city and highly respected by all your associates. The manner in which you have discharged the duties of the very responsible position which you have filled for so many years has been entirely satisfactory, and you are entitled to the thanks which I herewith tender you for the faithful and efficient manner in which you have attended to and discharged your duties as Chief of the Bureau of Gas."——Mr. Duncan Jones, Secretary of the New Orleans (La.) Gas Light Company, announces that the regular semi-annual dividend of 3 per cent. is payable on the 15th inst.——The rumors to the effect that the Cincinnati Gas Light and Coke Company is endeavoring to secure control of the local Edison Company are said by authority to have no foundation.——The Peru-La-Salle (Ills.) Gas Light and Power Company has been incorporated by Messrs. W. B. McKinley, Chas. Zilly and F. M. Zilly. It is capitalized in $130,000.

[Prepared for the JOURNAL.]

The Heat of Revivification.

By MR. HERMAN POOLE, F.C.S.

The material now generally used for purifying crude gas consists of a mixture of hydrated iron sesquioxide and a filling material, usually wood chips, shavings or sawdust. This woody matter does not help directly in the purification, but mechanically is of great assistance in preventing the caking tendency of moist iron oxide, as by its means the whole mass is kept loose and porous. As the rapidity and thoroughness of purification depend on the intimate contact of the gas with the purifying material, this loosening of the mass by the chips is of great benefit. Another view to be taken, however, is that the danger from fire is also much increased by such addition of a very combustible substance, in a form most favorable to such combustion.

The wood can be omitted in considering the chemical action going on in the purifying material and its subsequent revivification; and so, for the purposes of this discussion, we will at present consider the mass as consisting substantially of sesquioxide of iron united and mixed with more or less water of hydration and hygroscopic water.

The usual method of using the material in the purifying box is to arrange it in layers of more or less thickness, according to circumstances and to the ideas of the manager, and pass the gas into the box through the purifying material and then out again. As the change produced is a chemical change, and as all chemical changes need time, the gas passes slowly through, permeating every pore, thus allowing the oxide to act on the sulphureted hydrogen and "fix it," as it is termed. I say sulphureted hydrogen, without mentioning the other constituents, as that is the main impurity now in the gas, the other bulky ones having been previously removed. The comparatively small quantity of cyanogen compounds need not be considered, as no additional facts would be gained, but the calculations rendered much more complicated.

The iron oxide is in the condition of a hydrated sesquioxide, and for our purpose at present it does not make much difference whether it be $Fe_2O_3 3H_2O$, $Fe_2O_3 H_2O$, $Fe_2O(HO)_4$, or any other formula, since but very little absolute difference in the results would be thereby made, and no general difference. Being as simple as any, I shall take $Fe_2O_3 . H_2O$.

The gas arriving at the purifying box meets the iron oxide in a condition ready to unite with it and produce a compound containing the sulphur and the iron. Using our formula $Fe_2O_3 . H_2O$, we can have one of two reactions—

$$Fe_2O_3 . H_2O + 3H_2S = 2FeS + S + 4H_2O; \text{ or,}$$
$$Fe_2O_3 . H_2O + 3H_2S = Fe_2S_3 + 4H_2O.$$

There are undoubtedly a number of side reactions, but they are of no account in this discussion; neither is the actual state of affairs in the above formulæ of vital importance.

These reactions start with the entrance of the gas and go on until the oxide has ceased to work, and we will suppose it contains all the sulphur it can take up. Now, the material is ready for revivification. This consists in so acting on the iron sulphide or sulphides with oxygen in such way that the iron is reoxidized and the sulphur liberated in a free state. This is usually done by exposing it to the action of the air and moisture, turning it over at intervals, breaking up lumps, etc., and facilitating the even action generally. The formulæ representing this change are not yet settled, but we will take the following as answering our purpose to fair intent:

$$Fe_2S_3 + 3O + H_2O = Fe_2O_3 . H_2O + 3S.$$
$$6FeS + 9O + 3H_2O = 3Fe_2O_3 . H_2O + 6S.$$

Whether these formulæ are correct or not is of no account, as the fact is sulphur and iron oxide are produced, and we only deal with results now.

We have our formulae; now let us see where the heat comes from and how much there is produced. The discussion of this may be considered under several heads. First, where pure hydrated oxide is used, as is done by some experimenters; second, where the hydrated oxide is mixed with hygroscopic water; third, where the oxide is mixed with water, chips, etc., as actually occurs in the purifying box. A fourth one might be considered—that in which pure anhydrous sesquioxide is used; but as this case rarely occurs it is of more theoretical than practical value—the results would be similar, but on an exaggerated scale.

Fe_2S_3 is composed of—

Iron	50.4 per cent.
Sulphur.....	49.6 "
	100.00 "

One pound of iron uniting with one equivalent of sulphur generates 634 heats units or calories. Then 0.504 pound of iron uniting with 1½ equivalent of sulphur would generate—

$$0.504 \times 1.5 \times 634 = 479 \text{ heat units.}$$

This represents the amount of heat generated by the union of the elements, and also the amount required to decompose that union, hence that quantity of heat must be deducted from that which is actually produced.

FeS is composed of—

Iron	63.6	per cent.
Sulphur	36.4	"
	100.00	"

In this case, 0.636 pound of iron unites with one equivalent of sulphur, and hence the heat generated would be—

$$0.636 \times 634 = 403;$$

which is also to be deducted as with the 479 above.

Fe_2S_3, where oxidized, produces iron sesquioxide and sulphur, by the equation—

$$Fe_2S_3 + 3O + H_2O = Fe_2O_3, H_2O + 3S.$$

Hydrated iron sesquioxide is composed of—

Iron	70	per cent.
Oxygen	30	"
	100.00	"

We started with 0.504 pound of iron in the Fe_2S_3, then we will need 0.216 pound of oxygen and 0.081 pound of water to form 0.801 pound of hydrated sesquioxide of iron. The use of this oxygen would introduce—

$$3.32 \times 0.216 = 0.717 \text{ pound of nitrogen.}$$

One pound of iron burnt to sesquioxide generates 1,600 units of heat; 0.504 pound would produce, then:

$$0.504 \times 1{,}600 = 806.4 \text{ units.}$$

From these we subtract the 479 units needed to decompose the Fe_2S_3, and we have—

$$806.4 - 479 = 327.4 \text{ units,}$$

as the net result of the decomposition and oxidation.

FeS produces a similar result, to Fe_2S_3, as is shown by our equation—

$$6FeS + 9O + 3H_2O = 3Fe_2O_3, H_2O + 6S.$$

The 0.636 pound of iron in this FeS will need 0.273 pound of oxygen and 0.101 pound of water to form 1.01 pound of hydrated sesquioxide. The use of the oxygen necessitates the introduction of 0.906 pound of nitrogen. One pound of iron burnt in oxygen to sesquioxide produces 1,600 heat units; 0.636 pound would generate 1,017 units, and we have—

$$1{,}017 - 403 = 614 \text{ units,}$$

as the net result of the reaction.

We have thus obtained the actual heat units generated, but to ascertain the sensible or apparent heat we must consider the specific heats of the substances involved, and divide the net heat units by the sum of the products of the weight and the specific heats of these substances.

The specific heat of the substances under consideration may be taken as follows:

Iron oxide	0.166	specific heat.
Sulphur	0.200	"
Water	1.000	"
Aqueous vapor	0.480	"
Wood	0.300	"
Nitrogen	0.244	"

Fe_2S_3. First Case.—This is the one in which we consider the material as pure hydrated oxide. We then have, using air as an oxidizer:

$$\frac{327.4}{0.801 \times 0.166 + 0.496 \times 0.2 + 0.717 \times 0.244} = 804° \text{ (1,479° F.)}$$

If pure oxygen had been used, the equation would result in a temperature of 1,400° (2,552° F.)

This case is not very apt to occur in practice, but shows what increase is possible under favorable conditions.

Second Case.—Here the mass is considered as being composed of the oxide above and hygroscopic water, and assuming this water to be 25 per cent. of the entire mass, we would have—

$$\frac{327.4}{0.801 \times 0.166 + 0.496 \times 0.2 + 0.717 \times 0.244 + 0.2 \times 1} = 539° \text{ (1,002° F.)}$$

With pure oxygen as an oxidizer, this temperature would reach 758° (1,396° F.)

Third Case.—Here the mass contains wood chips also. As usually made iron mass contains about 70 per cent. of iron oxide and 30 per cent. of chips. To this is added water, and there is formed in a short time more or less sulphur, which exists as such in the material. We will suppose the following composition for our mass:

Iron oxide,	35	per	cent.,	or by weight,	0.28 lb.
Wood,	15	"	"	"	0.12 "
Sulphur,	25	"	"	"	0.20 "
Water,	25	"	"	"	0.20 "

To oxidize this needs an amount of oxygen which would introduce 0.251 pound of nitrogen.

Reducing our iron oxide to 35 per cent. has reduced the amount of heat units proportionately. We would then have 114.6, instead of 327.4 heat units; and our equation would become:

$$A. \quad \frac{114.6}{0.28 \times 0.166 + 0.12 \times 0.3 + 0.2 \times 0.2 + 0.2 \times 1 + 0.251 \times 0.244} = 300° \text{ (572° F.)}$$

At this temperature a portion of the hygroscopic water would disappear as vapor, using up a portion of the heat. If we imagine one-half of the water vaporized, the heat units would be reduced to 114.6—96.6 = 18.0, and the equation becomes then—

$$B. \quad \frac{18}{0.28 \times 0.166 + 0.12 \times 0.3 + 0.2 \times 0.2 + 0.1 \times 1 + 0.1 \times 0.48 + 0.251 \times 0.244} = 54° \text{ (129° F.)}$$

It would not be possible to volatilize all the water, as the temperature is now reduced below the boiling point and not quite up to scalding.

FeS. First Case.—Using the figures obtained above, and the same formula as used for Fe_2S_3, with the necessary changes, the equation becomes—

$$\frac{614}{1.01 + 0.166 + 0.364 \times 0.2 + 0.906 \times 0.244} = 1{,}310° \text{ (2,390° F.)}$$

Second Case.—This would become similarly—

$$\frac{614}{1.01 \times 0.166 + 0.364 \times 0.2 + 0.906 \times 0.244 + 0.2 \times 1} = 900° \text{ (1,652° F.)}$$

Third Case.—In this we shall have, as above—

Iron oxide	0.354	pound.
Wood	0.152	"
Sulphur	0.253	"
Water	0.253	"

The nitrogen introduced would be 0.317 pound.

Our heat units available have also been reduced to 205, and we then have

$$A. \quad \frac{205}{0.354 \times 0.166 + 0.152 \times 0.3 + 0.253 \times 0.2 + 0.253 \times 1 + 0.317 \times 0.244} = 420° \text{ (788° F.)}$$

B. The vaporized water becomes 0.126 pounds, needing 122 units, and leaving available 205 — 122 = 83.

The equation then becomes

$$\frac{83}{0.354 \times 0.166 + 0.152 \times 0.3 + 0.253 \times 0.2 + 0.127 \times 1 + 0.126 \times 0.48 + .317 \times .244} = 200° \text{ (412° F.)}$$

This heat is still enough to vaporize some more water, but not enough to be actually dangerous.

In examining these results we see that the compound FeS produces more heat than Fe_2S_3, and we see that if possible the use of pure oxygen would tend to greatly increase the heat produced. This does not mean that the actual amount of heat varies, but only the sensible heat, the difference being due to circumambient substances.

The oxidation of FeS can produce varying temperatures, according to conditions, up to 420°, and that of Fe_2S_3 will produce, under the same conditions, temperatures up to 300°. As these two are usually mixed, the extreme temperature possible is probably not over 350°. This temperature, however, is high enough to char wood and ignite sulphur, and this once kindled generates local heat enough to start the wood, which, when lighted, will continue to smoulder until quenched.

If the temperature once reaches the point of vaporization of water the hygroscopic water is driven off, and a condition of affairs, like that shown in the equations of the first case, is reached, which, if allowed to proceed, will soon ruin the material. This occurs at times in the revivifying mass, either in the box or on the floor, although more apt to occur in the former place. When it does happen a thorough breaking up of the agglomerated material is necessary, accompanied by a thor-

ough cooling with water. It will be noticed that these localized hot spots are incrusted agglomerations of material which have undergone a change, differentiating them from the rest of the bed.

The changes produced in the revivification need heat to a moderate degree to keep them in progress, but the heat must be regulated. Usually enough is produced in the mass itself, yet sometimes an additional small amount will do wonderful service. Steam has been used as being the ideal auxiliary, having both heat and moisture; but the steam when it reaches the box is usually quite damp, and soon cools down, so that the amount of moisture carried in is too much for the amount of heat. The best method of applying heat, if needed at all, is to warm the pipe conducting the air to the box, but by this method it needs watching.

The effect of water on the material undergoing revivification may be judged from the fact that the addition of 25 per cent. to the oxide causes a lowering of 270° in temperature, and if this water were evaporated this would use heat equal to another fall of 270°, and, in the case of each of the sulphides, the danger line would then be passed.

Determining the Efficiency and Loss of Heat in Gas Stoves.

The *Journal of Gas Lighting* recently published the following abstract of an article (named in the heading originally contributed by Dr. F. Haber, of Carslruhe, Germany, to the *Journal für Gasbeleuchung*:)

Notwithstanding the fact that from 1878 onwards Dr. Bunte has demonstrated that the efficiency of combustion can be ascertained very clearly and simply by calculation from the volumes, instead of the weights, of the products of combustion, few have learnt to avail themselves of the advantages of the method. The following example of the estimation of the duty of a gas stove, will serve to show how much less cumbersome it is than the methods commonly employed.

For determining the duty of a stove, the necessary data are: (1) The calorific value of the gas used; (2) the volume of carbonic acid and aqueous vapor produced by the combustion of 1 cubic foot of gas; (3) the percentage by volume of carbonic acid in the flue gases; and (4) the difference between the temperature of the ingoing air and the outgoing flue gases.

The determination of the calorific value of the gas is best made by means of Junkers' calorimeter, of the manipulation of which Dr. Bueb has given a good description. The calorific value, however, is found on the basis of the water produced by the combustion being in the liquid state. The flue gases are at the temperature of the room, and cannot carry away the whole of this water in a state of vapor; and therefore the latent heat of the condensed water is included in the value found by the calorimeter. An element of uncertainty is thus introduced into the estimation, as the amount of the water produced by the combustion passing away as vapor, and the amount condensed as liquid, are unknown. The flue gases are saturated with aqueous vapor at the temperature of the room. But the gas and air supplied to the apparatus are not necessarily so saturated; and hence water produced by the combustion may partially go to saturate the flue gases and escape condensation. Taking the extreme case of 1 cubic foot of dry gas mixed for consumption with 10 cubic feet of dry air, and yielding 25½ grammes of water among the products, if the volume of the flue gas be reckoned as 11 cubic feet 6.35 grammes of water will be necessary to saturate it at a room temperature of 73.2° F. (1 cubic foot is saturated by 0.577 gramme of aqueous vapor at that temperature.) Therefore the water condensed will be only 25.5—6.35 = 19.15 grammes, instead of the 25.5 grammes derived from the combustion; and the latent heat liberated in the calorimeter will be only about 11.5, instead of 15.3 calories. Thus the calorific value found will be 3.8 calories too low. The conditions here set forth are exceptionally unfavorable, and would never be found in actual practice. For instance, gas is often supplied through wet meters, and is then saturated with moisture. Moreover, the air of the room is seldom free from moisture; and, further, the volume of permanent gases will have undergone diminution by the combustion, and therefore there will be a smaller volume of flue gas to be saturated. In practice, therefore, the error is less than that shown above; but nevertheless it is an uncertain quantity. In the case considered, if allowance is made for the contraction on combustion, and if the gas is taken as saturated, 20.5 grammes of water will be condensed; but if the air supplied is also saturated, then 26.3 grammes of water will be condensed. The calorific value found will be about 2.9 calories too low in the one, and about 0.5 calorie too high in the other case. Though the error be not large, its amount is unknown; and since it can be avoided, it is better to give up this method of calculating the calorific value from the data afforded by Junkers' calorimeter, in all cases where precision is desired.

The better method of making the calculation is to deduct from the observed calorific value the heat of vaporization of all the water condensed in the calorimeter, which may be found by Clausius' formula $r = 607 - 0.708t$, in which t = the temperature of the water expressed in degrees Centigrade. The calorific value of the gas, when the water produced on combustion remains in a state of vapor, is thus found. This value is free from all uncertainties except those attributable to the calorimeter itself, and represents the ideal duty to be achieved in gas stoves; for in almost all the latter, it is considered desirable to allow the moisture in the flue gases to pass away uncondensed. If the calorific value when the moisture produced is condensed is, however, desired for any purpose, the heat of vaporization of the water produced by the combustion of a cubic foot of the gas—the amount is ascertainable in other ways—is added to the calorific value for the gas when the moisture produced remains as vapor. Or the moisture in the air entering the calorimeter can be determined.

Two very simple operations in gas analysis are required to determine the volumes of carbonic acid and aqueous vapor produced by the combustion of 1 cubic foot of gas. The first is an explosion in a suitable apparatus of a few cubic centimeters of the gas, carefully measured, with a sufficient volume of air, and the measurement of the carbonic acid produced. The operation should be performed over mercury. It gives directly the amount of carbonic acid produced by the combustion of a cubic foot of the gas. The second operation is the analysis of the spent gas from a gas flame collected by means of the funnel devised for the purpose by Dr. Bunte. Three figures are obtained in this analysis—viz., x = percentage of carbonic acid (by absorption with solution of potash); y = percentage of oxygen (by absorption with phosphorus); and z = percentage of nitrogen (by difference). Therefrom it follows that $\frac{100\,y}{20.9} = 4.785\,y$ = the surplus air, and $(100 - 4.785y)$ = the mixture of carbonic acid and nitrogen produced by the combustion of the gas with the amount of air demanded by theory. The following example explains the procedure.

Percentages found: Carbonic acid, 7.60; oxygen, 6.34; and nitrogen, 86.06. Then the surplus air amounts to $4.785 \times 6.34 = 30.34$; and therefore the carbonic acid-nitrogen mixture from the actual combustion $= 100 - 30.34 = 69.66$, of which 7.60 has already been found to be carbonic acid—leaving a residue of nitrogen = 62.06. This volume of nitrogen is clearly the residue of the air of which the oxygen was consumed in the combustion of the gas, and yielded 7.60 of carbonic acid. But 79.1 volumes of nitrogen are associated with 20.9 volumes of oxygen in air. Therefore the oxygen used in the combustion amounts to $\frac{20.9 \times 62.06}{79.1} = 16.40$. But when carbon is burnt to carbonic acid, the oxygen used is equal in volume to the carbonic acid formed. Therefore 7.6 of this 16.4 volumes of oxygen are consumed in producing the carbonic acid—leaving $16.4 - 7.6 = 8.8$ volumes of oxygen available for the formation of water. Then 8.8 volumes of oxygen form 17.6 volumes of water vapor. The ratio of carbonic acid to water vapor produced is thus found—*i.e.*, 7.6 volumes to 17.6 volumes—and from the explosion, the actual volume of carbonic acid produced from a cubic foot of gas has been ascertained. The actual volume of water vapor produced in the combustion of a cubic foot of gas is then arrived at by simple proportion.

The same result may be found graphically. On both axes of a system of co ordinates, the figures 0 to 20.9 are set out at equal distances; and a line is drawn from the origin to the point of intersection of the ordinate and abscissa at 20.9. Then, with the percentage of carbonic acid in the spent gas as ordinate, and the sum of the percentages of carbonic acid and oxygen as abscissa, an intersecting point is found, through which and the point 20.9 on the abscissæ axis a line is drawn and prolonged until it cuts the line passing through the origin and the point of intersection of the abscissa and ordinate at 20.9. The point where these lines cut has ordinate and abscissa of equal length, and the figure representing that length is the percentage of carbonic acid in the gas theoretically formed by the combustion. The percentage of nitrogen in the same gas is given by subtracting this figure from 100, and on multiplying the remainder—*i. e.*, the percentage of nitrogen—by 0.26423, the volume of oxygen consumed is found. Then, as before, the volume of water vapor formed is double the difference between the volume of oxygen and the volume of carbonic acid formed by the combustion. In practice, this graphic method is very rapidly executed.

An exact result must be insured by making several analyses of the spent gases from the flame. Three or four should suffice if the analyst is a competent man, and these can be made in about 20 minutes, if several burettes (Hempel's or Bunte's) are used side by side. The method is not only incomparably easier and quicker, but also more reliable than the deduction of the amount of hydrogen from a complete analysis of the coal gas. It, however, introduces one error; but it is a small one, and therefore negligible. Coal gas contains oxygen and nitrogen, and the ratio of the latter to the former is greater in it than in air. For instance, Carlsruhe gas contains 1.5 per cent. of nitrogen, in addition to 1.5 per cent. of air. The air introduces no error; but the 1.5 per cent. of nitrogen causes one of small but determinable magnitude. When Carlsruhe gas is burnt without a surplus of air, a mixture consisting of 11.6 per cent. of carbonic acid and 88.4 per cent. of nitrogen, is obtained. A cubic foot of the gas yields about 0.57 cubic foot of carbonic acid. Therefore, 11.6 volumes of carbonic acid arise from 20.35 volumes of coal gas, of which 0.3 volume will be nitrogen. Thus only (88.4 — 0.3 =) 88.1 volumes of nitrogen are derived from air; and the oxygen consumed is not 0.26423 × 88.4, but 0.26423 × 88.1—that is, not 23.37 volumes, but 23.29 volumes. The water vapor formed at the same time as the 11.6 volumes of carbonic acid becomes 23 38 volumes, instead of 23.54 volumes. The volume, in other words, is smaller by about 0.68 per cent. than it would be if the correction were not made, and so small a deviation is of no moment in the estimation of efficiency, as will be evident later.

There is no special risk of error in ascertaining the data referred to under heads (3) and (4); and therefore we may pass at once to an example of the determination of efficiency from the following data: (1) The calorific value of the gas, supposing the water produced by combustion remains in a state of vapor, is 138¼ calories per cubic foot. (2) One cubic foot of the gas produces 0.57 cubic foot of carbonic acid and 1.157 cubic feet of water vapor. (3) The flue gases contain 2.9 volumes per cent. of carbonic acid. (4) The difference between the temperatures of the ingoing air and the outgoing flue gases is 110° C. (230° F.).

A cubic foot of flue gases contains 0.029 cubic foot of carbonic acid; and since 0.570 cubic foot of carbonic acid is produced with the liberation of 138¼ calories, the production of 0.029 cubic foot is accompanied by the liberation of 7.06 calories. These 7.06 calories heat 1 cubic foot of dry flue gases, *plus* the water vapor accompanying 0.029 cubic foot of carbonic acid—which will, according to (2), amount to 0.05887 cubic foot—to an initial temperature of 747.9° C., as is evident from the calculation—

	Specific Heat Calories per Cubic Foot.		Calories.
0.029 cubic foot of carbonic acid....	0.01209	=	0.00035
0.971 " " nitrogen + air...	0.00869	=	0.00844
0.05887" " water vapor.....	0.01096	=	0.00064
Total heat necessary to raise 1 cubic foot of flue gas 1° C.....		=	0.00943

Therefore, 7.06 calories will raise 1 cubic foot of flue gases by $\frac{7.06}{0.00943} = 747.9°$ C. But the flue gases actually leave the stove at a temperature 110° C. above that of the air entering it. Therefore the heat carried away by them is $\frac{110 \times 100}{747.9} = 14.7$ per cent. of the total heat. Hence the available heat amounts to 85.3 per cent. of the calorific value of the gas.

It is evident that the error of 0.68 per cent. in the determination of the water vapor referred to above is insignificant, as the correction would only affect the sixth decimal place in the value 0.00943. It might also appear desirable to split up the 0.971 cubic foot of air and nitrogen into nitrogen and oxygen, and make a separate calculation for each of these gases, as their specific heats are not exactly the same. A closer inspection will show, however, that this extra labor is superfluous. The specific heats under constant pressure per cubic foot are: Nitrogen, 0.00868; oxygen, 0.00880; and air (by calculation), 0.00870. The specific heat of the mixture of nitrogen and air occurring in the flue gases will approximate to that of air the greater the excess of air, and to that of nitrogen the smaller the excess of air. The greatest error in the total value that can arise from this source amounts to only 0.15 per cent.; and it is therefore quite permissible to adopt 0.00869 for the specific heat of the mixture of nitrogen and air in the flue gases.

On surveying this method of calculating the efficiency of gas stoves, it will be seen that neither an analysis of the gas, a specific gravity determination, nor a knowledge of the consumption of gas per hour is required. The last item is, however, a useful accessory to the efficiency estimation, as it indicates the conditions under which the determination is made—*i. e.*, whether or not the stove is burning at its full consumption.

Address of Hon. Joseph H. Choate on the Occasion of the Opening of the New House (N. Y. City) of the American Society of Civil Engineers.

Mr. President and Ladies and Gentlemen: Unfortunately for you I have received no intimation to be brief (laughter). But my safety lies, and yours, too, in my little knowledge of the subject in hand (laughter). It was a great philosopher who said "One thing I know—that I know nothing," and always afterwards he was regarded as one of the greatest and wisest of mankind. But I do feel very grateful for the opportunity that has been given me on behalf, as it was suggested by the Committee, of the other professions, of welcoming this youngest, most vigorous, and, I believe, most useful, of all the learned professions in this very critical and important day in its life (applause). There is necessarily a fellowship and a very close fellowship among all the learned professions. We are all engaged alike in studying and applying laws to the uses and convenience of mankind, and in that respect the engineers, as it seems to me, have a very decided advantage over the other and older professions. They work from known and certain premises to inevitable conclusions. Theirs is an exact science, based not upon opinion, based not upon judgment, but upon absolute and fundamental facts in respect to which they ought not and cannot be allowed to err. But we of the other professions stand very differently. Ours are all uncertain—based upon opinion, upon experiment, upon judgment. When the doctor loses his patient, it is never his fault (laughter). He goes on, he lives on, and acquires new patients and new fame (laughter). When the lawyer loses his case, it is never his fault (laughter). He can always trace it to the infirmities of the law, or the weakness of the judge, or the dullness of the jury, or the evil conduct of his client (laughter). But it is not so with the engineer—the civil engineer; with him a blunder is indeed a crime. If his bridge falls, he falls with it. If his tunnel collapses, he collapses with it—and had better be buried in its ruins. Now, there is another respect in which, as I think, the profession of engineering has another very decided advantage over us. Our works perish. The breath of the lawyer is the measure of his fame. The rules, the practice and the law of the medical profession change from age to age, and—if the Bishop will allow me to say so—even the dogmas of theology are not forever unchangeable (laughter and applause). But the works of the engineer live after him as an enduring monument to carry down to a distant posterity his merits and his defects.

In a little term of leisure last winter I wandered over the Island of Sicily, and on the heights of Urias, overlooking what once had been the site of the city of Syracuse, which had absolutely disappeared so that not a vestige of it remained. The great fortifications that the predecessors of Archimedes had built under that lofty hill remained unchanged as they were built for military purposes more than 2,000 years ago. At Girgenti and Pæstium we gazed upon temples still standing, in form perfect, as they were erected by engineers and builders whose names have been forgotten, still holding out models of beauty and grace for the imitation and instruction of mankind. At Rome we rode over the bridge of St. Angelo, more than 1,000 years old. We stood under the dome of that matchless model of architecture, the Pantheon, as perfect apparently as when the name of its builder, Agrippa, was emblazoned upon its front. We stood before the ruins, the matchless ruins, the splendid ruins, of the Coliseum. All these great structures testifying to a far-distant posterity of the power and the beauty that dwelt in the minds of their designers; and I have been wondering since I was invited to take part in these proceedings whether any works yet constructed by engineers or builders in this America of ours shall last as long as those; whether the men of the thirtieth century, the students of architecture, of engineering, will find something yet to admire, even though it be in ruins, of the works of the men of the nineteenth and the twentieth centuries. That question I shall prefer to leave to these distinguished experts who are members of this American Society of Civil Engineers. But the truth nevertheless does remain that the work of these great engineers of to-day, the men who build our great bridges, our great docks, our great tunnels, our great railroads, will be carried down to a posterity that will long since have forgotten the doctor, the lawyer, and even the clergyman, who are now ruling over us.

I think it a very fortunate thing in respect to these days and events that the opening of this building for the use of the American Society of Civil Engineers is exactly coincident with the starting of this great

metropolis in which we live and of which, in spite of its mistakes, we are all so proud, upon its new and greater career (applause.) Why, New York is only an infant to-day. She is just bursting her swaddling bands. She has outgrown herself, and is really bursting her bands in all directions. You cannot venture into the streets without the peril of losing your life as a sacrifice to the great engineering works that are going on to-day (applause and laughter). And I am sure that that great province for engineering now extending over an area of 350 square miles—359 square miles is the exact quantity—holds out more work for the conscientious, the intelligent and the skillful engineer than all America did 50 years ago. (Applause.) What bridges are to be built over these noble rivers! What tunnels are to be excavated? What roads laid out! What docks constructed! Why, think of it; we have one project now pending before us, one work of tunneling and of bridging and of road building at an expenditure—the appalling expenditure of $50,000,000! Now, what I hope is that the new administration which the people of this city in their wisdom have elected to preside will come here—I hope they are here (laughter)—I hope the Mayer-elect is here—to learn a lesson that no other place could teach as well as this; that the great engineering works of this city, which are to absorb millions upon millions of the people's money and occupy years and decades in their construction, shall be placed under the charge of competent engineers as the heads of the departments, in which the public works belong. (Great applause.) I think the science of engineering has advanced so far, and I hope the science of municipal government has advanced so far, that hereafter it will not be considered sufficient to have as Commissioner of Public Works, either a lawyer or a politician, who is as ignorant of engineering as the unfortunate person who now has the honor of addressing you. (Laughter).

This Society well calls itself the American Society of Civil Engineers, because it is a truly national institution for the service of the whole nation, made up of educated engineers, engineers in every branch of civil engineering. Now, President Schurman has said something about its being a new profession, and General Craighill asserted that it was the oldest profession that he knew anything about. Well, that is only a difference of verbiage of phraseology. It is true that 50 years ago there were not many civil engineers, and if they had been presented to an audience like this, the audience would have have been quite at a loss to know what they were. (Laughter). But they have been training, and are being trained from the beginning. It is true the colleges did not do much for them. I remember when ex-President Morrison, one of the most distinguished engineers of this country, and one of the most distinguished ex-Presidents of this Society, left Harvard College, he found it necessary to spend a year or two in my law office to lay the foundations of that great engineering fame. (Laughter and applause.) And I am happy to say now that three successive Presidents of this Society, including the gentleman who presides here to-day, are graduates of Harvard College. I think it shows what we believe in the other professions—that for technical education there must first be laid as a foundation a broad, liberal education. (Applause.)

But I was going to say what the engineers had done for the nation. It is true they have not been the founders of the nation; but they have been the makers and the builders of the nation. Now, let us see exactly how that is in a very few words. When this nation was founded, for I look upon the making and adoption of the Federal Constitution in 1787 as the founding of the nation, there had been no engineering and no engineers in America except the military gentlemen whom Washington had summoned to his aid for the conduct of the war. There was no bridge over any navigable river in what now constitutes the United States; no harbor but presented its natural appearance as it had been from the beginning of time. Of course, no railroads, no tunnels, no roads worthy of the name, of any description. Why, then, it took the members of Congress who went in their own carriages from Boston to Philadelphia six days to make the journey, and they had to cross in ferries the mouths of six navigable rivers. Two hundred years had been spent by the settlers in grappling with the wilderness, and in desperate struggling. What had been accomplished? Fifty miles in breadth along the Atlantic coast, from Maine to Georgia, was all that then represented the triumphs of those two centuries. Well, then, the Federal constitution was adopted. You remember that memorable scene on the day when Hamilton wrote the names of the States on the last page of the document, at the foot of the document, and Washington and Franklin and all the rest of them subscribed their names. Franklin, looking at the painted sun that was behind the chair of Washington, who presided in the convention, said: "All through these debates I have been wondering whether that was a rising or a setting sun. Now that these names have been signed to that immortal document, I am sure that it is a rising sun." But if Washington and Franklin, the two wisest members of all that wise gathering, could have foreseen that within a hundred years the area of the United States—in which the constitution which they then formed was to carry the blessings of liberty to a distant posterity—was to extend not simply from the Atlantic to the Mississippi, but three times as far—from the Atlantic to the Pacific, and from the Gulf to the Lakes, and that in the ordinary administration of executive power it might be necessary for the President to issue an order, for the very salvation of the Republic, that should be obeyed within one hour on the Pacific Coast—if they had contemplated that it might be necessary to transport in three days 300,000 men from the Lakes to the relief of the beleagured capital—even they would have trembled at the sublime audacity of the experiment that they were undertaking (applause). Why Franklin himself, with all his power, with all his learning—he had snatched the lightning from the clouds and the sceptre from tyrants; he knew all about steam that anybody knew; he was the matchless master of electricity up to that date, and yet even he had no conception of the means and appliances by which this nation was after all to be made one. Let me read you what he said only the year after the convention adopted the Constitution and adjourned. In writing to a friend of his in the month of October, 1788, from Philadelphia, he says:

"We have no philosophical news here at present, except that a large boat rotated by the force of steam is now exercised upon our river, stems the current and seems to promise being useful when the machinery can be more simplified and the expense reduced." (Laughter).

And Mr. Madison, in the *Federalist*, in arguing very laboriously the possibility of the Federal Government exercising efficient control over our vast territory as it then extended from the Atlantic to the Misissippi and from Maine to Georgia, says:

"The difficulties will indeed be great, but as the nation will extend no further than the Mississippi and no further south than Georgia, it will be quite practicable for the delegation from those distant regions to reach the seat of government in time to take part in the deliberations of Congress." (Laughter).

And now what do you see? What has been done since then; all done by these engineers? As Mr. Seward said at the outbreak of the War of the Rebellion: "No parchments, no laws will hold this nation together; but bridges and railroads and steam and the telegraph, they will and must do it." (Applause).

Now, I will not detain you, for you all know what these engineers have done. The highway from the Atlantic to the Pacific was the very saving of our Pacific seaboard, the Rocky Mountain States, to the Union. You all know perfectly well what immense works, both public and private, have been constructed by them in every quarter of the Union; how peace and plenty, and order and law, and art and civilization have followed in their track; how they have made commerce so fruitful, the people so flourishing and happy and have brought with them to stay prosperity throughout the land. (Applause.)

Now, when I received this invitation I thought I would like to know something about some engineers, and I got one of the most entertaining books or set of books that I for one have ever read. As there are some here who are not engineers, I advise them to get it and read it, and that is Smiles' "Lives of the British Engineers." They are more fascinating, each one of them, than anything that can be found in the Arabian Nights—more bewitching in their fortune, their character and their achievements. They all seem to tell one story. They had no colleges, they had no universities where they could study the elements of their profession. They were almost uniformly sons of laborers, born in laborers' cottages, nurtured under hardships, apprenticed to a youth of hard labor, manifesting always indomitable courage, vast power of labor, a perfect passion for construction, and patience that knew no end, and courage that equaled anything that any warrior ever exhibited, and conscience always—it is one of the most honest and conscientious professions that has yet come into the world (applause). They stumbled upon their first works apparently almost by accident. They showed themselves worthy by the perfection of the work they did, the conscientiousness with which they did it, and they went on from one piece of work to another, ever greater and grander and grander; and when they were called to their last home they were followed to the grave, not by humble cottagers who had surrounded them at birth, but by kings and nobles and the intelligence, the brains, the culture and the wisdom of the realm. Where did they end their careers? Just where they should, among the greatest benefactors of mankind, in Westminster Abbey. Doubtless all of you remember that splendid statue of Watt, to whom President Schurman has already referred, by Chantry, on which is inscribed an epitaph prepared by Lord Brougham

which he counted the greatest honor of his life to have been permitted to write; and then, too, you find as you walk through the nave the graves of Thomas Telford and of Robert Stephenson—two more of the great benefactors of the human race—the one the "Colossus of Roads," as his friend Southey delighted to call him, the other the perfecter of the locomotive. He and his greater father—if I may be permitted to call him so—George Stephenson, had worked together in the development of that vast machine upon which now the prosperity of the human race itself depends.

Now, how did they do all this? How did these great engineers achieve those marvelous triumphs. Well, I think it was only—to borrow a phrase of Emerson's—by hitching their wagon to a star, and if you will permit me to read a few words from Emerson in conclusion, which I think he intended for just such an occasion as this, and in writing which I believe he had in mind the American Society of Civil Engineers and all civil engineers in general, you will understand what I mean when I say that, recalling Lord Bacon's phrase, that every man owes a debt to his profession, that the debt that these civil engineers owe is to follow in the footsteps of those great men whom they all unite in honoring and revering; and now, if you will allow me to read this short passage from Mr. Emerson, I will take my seat. He says:

"Now, that is the wisdom of a man, in every instance of his labor, to hitch his wagon to a star and see his chore done by the gods themselves. That is the way we are strong, by borrowing the might of the elements. The forces of steam, gravity, galvanism, light, magnets, wind, fire, serve us day by day and cost us nothing. Hitch your wagon to a star. Let us not fag in paltry works which serve our pot and bag alone. Let us not lie and steal. No god will help. We shall find all their teams going the other way—Charles' Wain, Great Bear, Orion, Leo, Hercules; every god will leave us. Work rather for those interests which the divinities honor and promote—justice, love, freedom, knowledge, utility. If we can thus ride in Olympian chariots by putting our works in the path of the celestial circuits, we can harness also evil agents, the powers of darkness, and force them to serve, against their will, the ends of wisdom and of virtue." (Prolonged applause.)

High Potential Insulators.

[By Mr. Frederic A. C. Perrine, D.Sc., in *Electrical Engineering*.]

In canvassing the possibilities of high potential power transmissions over long lines, some manufacturing engineers have been found who recommended voltages as high as 50,000, but those who have had experience in the operation of long transmission lines have intimated that even as much as 30,000 volts introduced insulation problems of great uncertainty, and, in consequence, a recently projected 75-mile transmission line in Southern California is looked upon with great interest on account of the fact that contracts are let for machinery to transmit the power at 33,000 volts. The interest in this problem centers upon the character of the insulators used upon the line, since all agree that the problem is entirely one which involves the character of the insulators and the manner of their installation. In such work all line covering has been properly abandoned, and the leakage from the line must be prevented by the insulators placed upon pins.

Porcelain and glass are the only materials which have been recommended for this purpose; while the consensus of opinion points to the future use of porcelain exclusively, for the reason that porcelain is not only intrinsically stronger than glass and its surface less liable to retain hygroscopically condensed moisture, but also on account of the fact that if accidentally broken or cracked a porcelain insulator is not necessarily shattered, as is almost invariably the case with one made of glass. The requirements, then, of a porcelain insulator, and the possibilities in the manufacture of porcelain, should be clearly understood before an engineer can draw satisfactory specifications for the material to be used in the construction of a transmission line.

Of the two questions—the requirements for a perfect insulator and the possibilities of attaining such perfection in manufacture—there is no doubt but that engineers from their general experience in insulation understand the necessary requirements much more perfectly than they understand the possibility of approaching these requirements in the manufacture of any artificial insulating material; this is particularly true of the material of porcelain. Nor is it strange that there should be an uncertainty in the minds of engineers as to the difference between good and bad porcelain for insulating purposes, since from the earliest history of the porcelain industry in Europe there has been much uncertainty as to the nature of the material itself. Many products of manufacture in the pottery kiln have been called porcelain which approached glass closely in brittleness, while others that are sufficiently tough are so porous and full of cracks that they are equally unsuited for use on a transmission line. Evidences of uncertainty concerning the characteristics of porcelain were very apparent in the recent discussions on the insulator question before the Pacific Coast Electrical Transmission Association which met at Santa Cruz, California, on August 17. No less than four of the papers then read discussed this question, while only one of the authors, and that one a manufacturer, seemed to possess a clear idea of what might be the characteristics of a satisfactory porcelain insulator. In the paper by Dr. C. H. Van Orden, in speaking of the burning of poles, due to the failure of insulators, he says: "The burning always occurred in these (green poles), and the defect was invariably in the topmost insulator when the ground was wet. The current escaped through slight cracks in the enamel, and crossing the *spongy, wet inner porcelain*[1] followed the iron of the V-shaped support and penetrated the cedar by the lag screws to find in the sap a good conductor to the moist ground. This thread of current heated, charred and consumed the inflammable wood."

Mr. T. W. A. Shock, in an article at the same time says: "In an insulator recently taken from the lines of the Sacramento Electric, Gas and Railway Company, and tested as to its porosity by immersing it in red ink, the writer found that the ink worked its way through the material to its surface where the glazing was worn off, showing that when the glazing was removed there was sufficient porosity to allow leakage through the material to the inner petticoat and thus to the pin. In most cases where the insulators were taken off the line they were removed from poles where bare copper conductors were used, and these insulators showed that the glazing was worn off where the wire came in contact with it by the working of the wire during winds or heavy storms. The glazing having been worn off, the current easily found its way to the pin, which meantime was also burned. This experience also seems to show that an extra heavy glazed surface is required. * * *"

These two papers seem to have repeated the best opinions presented before the congress, and it is remarkable that both of these authors spoke of porcelain as a material which is necessarily porous, and that they seemed to think the insulation of the line depends largely upon the character and thickness of the glaze, without knowledge of the possibility of obtaining a heavy glaze or a porcelain without porosity.

The material of porcelain is by most writers on the subject considered to be one of the two great divisions of ceramic ware, and it is distinguished from pottery by being more dense, whiter and less fusible, but particularly in being translucent. Indeed, many consider that translucency is the only means by which porcelain may be distinguished from pottery. Pottery is a ceramic ware molded from a paste of impure hydrated silicate of alumina, containing certain amounts of free silica, lime and iron. The product is opaque and invariably porous, on account of the removal of the volatile ingredients in the baking process. Porcelain, on the other hand, consists principally of a pure silicate of alumina only slightly hydrated, called kaolin, inclosed within a matrix of hard silicate glass. In the oldest history of the art the Chinese found pure kaolin in certain clay banks, and in other banks the ingredients for a silicate glass, which, being mixed together, molded and baked, formed what is called "natural" or "hard paste" porcelain. This was first imitated in Europe by "soft paste" porcelain, an admixture of the kaolinic clay with an artificial glass composed of a mixture of niter, soda, gypsum and salt, the proportion of kaolin to the glass being much less than in the natural Chinese product. Between these two lie the "mixed" or "bastard" porcelains, which are uncertain in character, but which are all composed of kaolin inclosed within a bond of more or less fusible glass. To this last class belong most of the American porcelains, although some of our potteries produce a material more like pottery than porcelain in porosity by mixing the ordinary grades of pottery clay with kaolin. When first baked, all of these materials are more or less imperfect over the surface, having much roughness and little luster, which surfaces must be finally protected by a subsequent glazing, the glaze consisting of nothing more than a thin coating of glass, which may be merely and entirely an artificial glass similar to that from which bottles are made, or a natural glass made by melting over the surface a powder of pure feldspar. We see then, in the first place, that the character of the insulating material depends upon the clays used and the percentages in which they are used, since by changing the ingredients we may pass from glass, which is melted and runs at a temperature a little above the red heat, through soft paste porcelains and mixed porcelains to hard-paste porcelains, which in the hardest grades cannot be melted at a tempera-

1. The italics are mine.

ture below 2,000° Fahr. Pottery can hardly be ranged in this series, nor is it proper to range here the so-called porcelains containing pottery clays, for the reason that the materials from which these articles are made all contain substances of a volatile character, and furthermore, these clays are deficient in fusibility, so that the ware is necessarily porous on account of the volatilization of water and other contents of the materials as they are molded before baking.

The general process of manufacture of the insulator for an electric line follows closely the processes that have been used in the manufacture of porcelain since the earliest times, with one important change, which is the result of modern inventive methods. The clays used are intimately mixed by grinding under water into a perfectly homogeneous mass, and after the superfluous water used in grinding has been removed by settling or filtering, the clays are molded into the shape required for the finished articles by either "casting," "throwing" or "pressing." The operation of "casting" is the one by means of which we obtain thin egg-shell china so much admired in our dainty teacups. For this purpose a mold of plaster of paris is furnished, which determines the outside shape of the article to be made. This mold is filled with a so-called "slip" of clay, about the consistency of cream; the plaster mold immediately absorbs the water and holds on its surface a layer of clay, the thickness of which is determined by the time the slip is allowed to stand. When the articles are thick enough, the remaining slip is poured out, the surface smoothed by a delicate touch or two and the teacup is ready for drying and baking. Larger and thicker articles have from time immemorial been "thrown" on the potter's wheel. For this work the slip of clay is settled and filtered, and the remaining mass of wet clay molded and dried until the correct plasticity is obtained, when it is taken by the potter and whirled upon his wheel, while with his hands he guides the jug into the shape desired.

Modern invention has almost superseded the potter's wheel by the potter's press, and by this press the tough hard-paste porcelain can be made into thick objects without porosity, as was formerly only possible with glass and soft paste material. For working in the press and to obtain a material of great density, the damp clay is further dried until it is in a powder which will not adhere in masses except under considerable pressure. This powder is then filled into a matrix and a core brought down; the sharp pressure consolidates the clay into the form of the finished article, the density of the resultant baked porcelain depending not only upon the proportion of the ingredients, soft and fusible, but also upon the amount of pressure applied; since as the pressure is increased the clay may be more thoroughly dried and smaller spaces left by evaporating moisture. Moisture cannot, however, be entirely eliminated from clay until it is subjected to the heat of a pottery kiln, and that this process removes a very considerable amount of water from the mass is shown by the fact that the shrinkage in baking amounts to about as much as the shrinkage in the cooling of cast iron, namely, a shrinkage of one-eighth in the linear dimensions. The spaces remaining are filled in the baking process by the fusible material with which the kaolin is mixed.

Whether "cast," "thrown" or "pressed," the articles made from clay are of consistency not different from that of a lump of clay until subjected to the heat of a pottery kiln, when the water of hydration is driven off from the silicate of alumina and any glass contained in the mass is fused, thus rendering the finished baked porcelain article hard and solid, the hardness and toughness depending largely upon the quantity and quality of silicate of alumina, while for the solidity we must look to the presence of a certain amount of fusible glass. The proper porcelain, therefore, for insulation, is that in which there is only that amount of glass present which is necessary to fill up the porosity of the dehydrated silicate of alumina, since when this proportion is attained the greatest amount of strength consistent with non-porosity is reached. Should the amount of glass be increased beyond this point, the porcelain will become brittle, although it will still be non-porous—but non-porous just as glass is non-porous—and hence without the advantage over ordinary glass supposed to be possessed by a hard-paste porcelain. If the amount of glass present is only so much as will fill up the pores left by the escaping water as the silicate of alumina is dehydrated, we can readily see that such porcelain has no property by means of which wide cracks in the molded clay can be stopped up, since at no temperature available within the pottery kiln will the mass fuse and run.

We may say that the glass is drawn by the porous silicate of alumina into itself by capillary attraction, and when spaces are present which are not capillary these spaces cannot be filled up; accordingly, we see that the solidity of the finished article in hard-paste porcelain manufacture depends upon the solidity of the molded clay, and we also see that it is erroneous to suppose that while the porcelain manufacturer can make thin articles which will be solid, it is impossible for him to obtain an equal solidity when heavy masses are dealt with. It is, indeed, more likely that the heavy articles will contain open spaces than that they will be present in thin pieces, since whether the pressure is applied on the wheel by the hand or in the matrix by the die, it is easier to make solid a thin layer of the clay than a thick one, but at the same time that porcelain manufacturer who does not increase his pressures sufficiently to insure the solidity of thick pieces is not handling his clays properly, and the fact that certain makers are not able to produce heavy solid articles does not tend to prove that solidity is an impossibility where the clays are properly handled.

Another danger must also be avoided in the choice of a porcelain insulator of great weight, which is harder to detect than the presence of porosity, since the exact knowledge of the mixture of clays used is only possessed by the manufacturer himself. I am speaking now of the tendency toward the use of soft-paste porcelain by manufacturers whose machinery is not powerful enough to compress the hard-past clay to a sufficient density for a perfectly solid heavy insulator. Of course, with what has gone before, we can at once see that should a manufacturer find that his mixture in heavy masses does not give a thoroughly solid product, he can at once add more glass, or glass of a more fusible character, reducing the amount of kaolin, on which we depend for strength. He will then obtain great solidity at the expense of toughness and strength. This is an error in the manufacture of insulators which can only be detected with the greatest difficulty, since the highest experts on porcelain wares are often at a loss to determine whether the body of an article is a hard or a soft-paste porcelain without determining the crushing strength, and of course a mechanical test is exceedingly difficult to apply to such an irregular body as a line insulator. Even the chemist is here upon ground in which he is not sure, since the differences between the clays and the glasses are chemically so slight that the result of an analysis is of very little worth. While this is undoubtedly the greatest difficulty in the matter of insulators for withstanding high potentials and carrying lines of great weight, it is the point in which the manufacturers are deficient in their apparatus, since there is hardly a factory in the country which is equipped for pressing the heavy high-voltage line insulator more solidly than articles much smaller are necessarily pressed, and in consequence it is probable that at the present time most of the manufacturers make an insulator which is either porous in a heavy body of the insulator head, or that a much softer paste is dealt with than is used for smaller articles.

Should a manufacturer attempt to mix and press a hard-paste clay which shall give a thoroughly solid line insulator of the greatest size, he would also encounter the difficulty that clay when pressed is not a liquid body, and in consequence pressure applied in one direction is likely to produce cleavage lines in the insulator, and in consequence we may not at the present time say that insulators of the form now used can be made solid from dry hard-pressed clay without danger of the production of such cleavage lines, and in consequence we must use a softer paste until the proper form of insulator shall be developed, or perfect the molding of the hardest part used in the driest possible state, and sufficiently hard pressed for complete solidity after baking. These cleavage lines are especially apt to occur where irregularities in pressure are sustained by the mass of clay in molding. That such irregularities must almost inevitably occur will be evident to one who examines carefully any insulator with long thin petticoats; and furthermore, this same examination will point to a danger of the petticoat splitting away from the head of the insulator in baking, when, as has been said, the shrinkage of one eighth occurs. The effect of this shrinkage is well known to ironmolders, and no competent pattern maker would attempt to join long thin plates to a heavy body without in some way taking care of their tendency to split away from each other when shrinkage occurs. In consequence, the most successful designers of articles for manufacture in pressed porcelain are those who have had thorough training in molding complicated cast iron shapes. Whether the petticoats are broken away from the mass of the insulator in pressing or in shrinking when they are baked, we find that most of the failures of such insulators when pierced by high voltages occur along cracks which are found in the porcelain at about the point where the petticoat is joined to the heavy head.

Coming from the kiln, articles made of hard-pressed porcelain, however smoothly molded and however solid in the interior, are found to have a surface which is dull and somewhat rough; and where a smooth shiny surface is desired, glaze must be applied. Glaze is a glass ap-

plied to the exterior surface of the baked porcelain and fused on by subsequent baking. The glaze is perfect when it flows evenly over the surface of the article, and when it does not crack on coming from the kiln, or subsequently when exposed to varying temperatures. Cracking of the glaze is technically termed "crazing," and crazing is due entirely to a difference in the coefficient of expansion between that of the glaze and that of the underlying biscuit. It would seem at once to be the most reasonable proceeding to glaze our porcelain biscuit with the material of its body; but if this body is that of a hard-paste porcelain it is not sufficiently fusible for use as a glaze, and in consequence the surface must be covered with something more fusible. Accordingly, the selection of a glaze which shall have the same coefficient of expansion as that of the porcelain body is a matter of the greatest difficulty. This difficulty increases as the thickness of the glaze is increased, on account of the fact that, while a thin glaze may have sufficient elasticity to give with movements of the underlying porcelain, a heavier body of glaze will not yield so readily.

That this should be true is apparent at once by the examination of a glass thread, which can be bent and even woven, while the glass rod from which it is made seems to be almost absolutely rigid. Tiles have been made with a glass face as much as one-sixteenth of an inch in thickness, but this was accomplished only after a long series of experiments, with repeated failures, and only on the surface of a rough tile made of porous firebrick. The natural hard paste porcelain of the Chinese is supposed to be glazed with pure feldspar, but a more readily fusible glass is required by almost all the European and American porcelains, while for each porcelain body a different glass is required; and not only is there probably but one glass which will glaze a particular porcelain, but also that porcelain manufacturer is to be congratulated for the care and success of his research after he has found a glaze which under no circumstances of changing temperatures will craze. Josiah Wedgewood spent many years of his life in ascertaining this fact and in determining the proper glazes for his different wares, while in this country thousands of dollars have been consumed by the different porcelain manufacturers in finding satisfactory glazes. In many cases such glazes have not yet been found, and in consequence but very few of our porcelain manufacturers can make a satisfactory line insulator without a crazed surface. That we should require a surface which does not craze is due to the fact that although we do not depend upon the glaze itself as an insulation, we do depend upon it for preventing the retention of moisture upon the surface of the insulator. The nonhydroscopic character of porcelain as compared with glass therefore depends upon the character of the glazing surface and also upon its mechanical perfection. There is here a danger in the use of some porcelains, that while when made the smooth glaze is nonhydroscopic, the glass necessary to use for glazing will be soluble, and when weathered will present a rough surface, even though no crazing should ever occur. Indeed, it is probable that all porcelain glazes will ultimately weather, since the hardest glass we know of is that made of pure feldspar, which, even a slight study of geology tells us, is destroyed by atmospheric influences, and this is an additional reason for turning our attention from the glaze to the porcelain body when we speak of insulation resistances; and even were this weathering of the glaze removed to a remote possibility, we do know that any glaze will be worn away from the insulator by the contact of the line wire which the insulator is destined to support.

Having now examined carefully the necessary details in the manufacture of porcelain for insulators, we are prepared to give some guide for the writing of proper specifications and the pointing out of tests which should be made upon a porcelain insulator in order to obtain the best product that our manufacturers can at the present time produce. It is useless for the engineer to attempt to limit the porcelain manufacturer to certain pastes or glazes, since the clays used by different makers, though bearing the same names in different parts of the world, are not all the same in ultimate character—one or two per cent. difference in the amount of water contained by the kaolin changing the whole character of the mixture necessary in the production of hard porcelain. And, as we have said, a different glaze is required for each mixture of clay, therefore these details must be left entirely to the manufacturer himself, since he is better able to make the choice necessary for a successful product than any engineer, no matter how carefully the latter has studied the use of insulators and the manufacture of porcelain. But, at the same time, the user should endeavor to ascertain which manufacturer uses the strongest paste and produces the densest insulator. Strong pastes can be chosen from soft pastes by mechanical tests alone, and the ability of the insulator to withstand shocks as well as pressure should be carefully tested.

In applying electrical tests it seems foolish to attempt only tests upon the finished glazed articles, since if the glaze is perfect it will completely mask the most serious extent of porosity, and even twice the potential of the line may not pierce a defective insulator, which will fail during the first rainstorm after the glaze has been worn away by the wire. The proper time, therefore, to apply any electrical test to the porcelain insulator is while the insulator is in the biscuit and before it has been glazed. It is always perfectly easy to test for porosity and to stamp the accepted insulators under the glaze by a mark which cannot be counterfeited after glazing has been performed. Even a galvanometer test at moderate potentials in this stage will furnish more accurate knowledge of the state of the porcelain than a high potential test after the glazing has been applied. Especially is inspection at this time important, as the glaze will mask cracks as well as porosity, which cracks would be apparent to the eye of the inspector before glazing, although completely covered by skillful work in the glazing process. The final inspection of the finished insulator should turn upon the perfection of the glazed surface, although it is foolish to attempt to obtain an insulator glazed in every part, since the insulator must be carefully supported in the glazing furnace, and where it is supported the surface will remain rough. It is indeed possible to specify the position upon the insulator of this rough surface, but one cannot expect to obtain a piece of porcelain covered with glaze in every part.

Finally, it should be pointed out that the relative positions of the wire and the petticoats demand some study, since if the petticoats are likely to be cracked away from the body of the insulator at their point of attachment with the head, it seems wise to remove the wire from this danger point as far as possible, although, of course, actual contact of the wire with a crack is not necessary for piercing through that crack, since the high potentials now used will leap along the surface of an insulator from 3 to 5 inches, and, in consequence, if the path from wire to pin through a crack is less than the sparking distance of the potential used, leaks will occur through a crack even though neither pin nor wire be in contact with it.

It certainly seems, therefore, that, although we may improve our present insulators by a careful study of their material and form, it is at present unnecessary to attempt any redesigning of the insulators in use until we have thoroughly tested the capabilities of our porcelain manufacturers to produce insulators of the present form which shall be sufficiently strong to carry the wire and sufficiently solid to prevent the escape of electricity through the body of the porcelain without reference to the character of existence of glazing.

One of the Useful Applications of the Storage Battery.

By Mr. William Baxter, Jr., in *Sci. Am.*

When the storage battery first came prominently before the world, it was thought that its great field of usefulness would be that of the transportation of energy from coal fields and large water power sites to centers of industry. It was also believed that it would enable the electric motor to become a formidable rival of the steam locomotive, not only because it would reduce the cost of hauling a train, but because, in addition, it would remove many of the objectionable features of steam transit, such as smoke, cinders, etc. When put to the test it was found that the batteries, at least as then constructed, could not withstand the hard usage to which they were subjected in railroad work; and as to their value as transferrers of energy from the source of supply to the points of demand, it was found upon investigation that they could not compete with existing methods, even if made sufficiently substantial to endure constant usage with slight deterioration, and so perfect electrically as to have the greatest storage capacity, per unit of weight, consistent with theoretical possibilities. In this latter field they would necessarily fail, because, if made as light as possible, they would weigh at least 12 pounds for each horse power hour capacity, and as good steam engines can develop the same amount of energy from 3 or 4 pounds of coal, the weight of batteries to be transported back and forth would be three to four times that of the coal necessary to do the same work. The batteries then made weighed from 150 to 200 pounds per horse power hour capacity, instead of 12; hence, the difference in weight to be transported under the actual conditions was so great as to render it impossible to accomplish anything practical in that field, even if the energy could be obtained free of cost.

When it was seen that the storage battery could not accomplish anything of a revolutionary character, those interested in its development began to study its adaptability to less pretentious work, and soon realized that it would be decidedly valuable as an adjunct to electric light-

ing stations, as it would be to these what the gasometer is to a gas distributing system—a reservoir from which the demand of customers could be supplied, should it become necessary at any time to stop the machinery for a few hours. Without the aid of storage batteries, if from any cause the operation of the generators is suspended, the lights will instantly go out and remain out until the generators are set in motion again. After years of persistent and very commendable experimental work, the inventors of storage batteries succeeded in making these devices sufficiently durable to withstand the wear and tear they are subjected to in station work, without unreasonable deterioration. Since that time they have been used to a considerable extent in that field, and within the last two years their use has been increasing at a very rapid rate; in fact, a first-class station of to-day would not be considered complete without a storage battery plant.

The first battery plants installed in lighting stations were intended simply as a safeguard, to render it possible to keep up a supply of current in case of accident to the machinery; but it was not long before it was realized that by enlarging the capacity of the batteries the output of the station could be greatly increased without materially increasing the expense of operation. How this result can be accomplished will be readily understood when it is considered that the demand for light is not uniform throughout the whole 24 hours, but varies from little or nothing, during the day and the early hours after midnight, up to the maximum amount between 9 and 10 in the evening. The station capacity, however, must be sufficient to meet the greatest demand; therefore, during the greater part of the time the machinery is only worked to a fraction of its full capacity. By using storage batteries, the generators can be worked to their full capacity all the time, and when the demand of consumers is small the surplus energy is stored, to be given out when the demand is in excess of the amount developed by the machinery.

From the very fact that the demand for current is variable, it becomes possible for batteries to be used not only to reduce the cost of production and increase the capacity of the station, but also to reduce the cost of line wire. This last result can be accomplished in any case where the station is located at some distance from the district in which the current is distributed. To illustrate this point, suppose the station is located say 1 mile from the center of the city or town in which the lights are used. If the current runs direct from the generators to the customers' lamps, the line wires must be of sufficient size to carry the maximum supply with a loss of pressure low enough to not interfere with the brilliancy of the light. If the maximum demand lasted for a considerable portion of the day, the full capacity of the line wire would be used to a reasonable extent, but the duration of this maximum demand is seldom over one-half, or, at the most, one hour; therefore, during the rest of the time a large portion of the line capacity may be regarded as wasted.

The difference between the average and the greatest demand varies within wide limits, in different stations, but in the majority the ratio is not much below one to two. Whatever it may be, however, if the current could be supplied at the average rate, and the excess over the demand when the consumption is small were stored, the amount so stored could be used to supply the deficiency when the demand is large. This is accomplished in many cases at the present time by placing a storage battery plant at the center of the district in which the customers are located. The wires coming from the generating station are so connected with the battery and the distributing mains that, whenever the drain is less than the current coming from the station, the batteries are charged, and when the demand is in excess of the current from the station, the battery feeds into the distributing mains. The current passing from the generating station to the battery station is about 10 per cent. more than the average demand, so as to cover the loss in the charging and discharging of the batteries.

The saving in wire by this arrangement will run from about 25 to 75 per cent., depending upon the relation between the average and the maximum current, and also upon the amount of energy that is lost in transmitting the current from the generators to the battery. When the generating station feeds directly into the distributing mains, the loss of energy in transmission is governed by the condition that the pressure of the current must not drop so much as to interfere with the brilliancy of the lights, and therefore the line loss is generally low; but when batteries are used, located at the center of distribution, they regulate the pressure of the current supplied to the lamps; and, therefore, the loss between generator and battery may be made anything desired, without affecting the brilliancy of the lights. If the power is obtained from a waterfall or from coal near a railroad, when it can be obtained at a very low price, it may be more economical to increase the loss of energy between generator and battery, and thus reduce the cost of line wire, but such conditions cannot be taken advantage of if the battery is not used.

The Gas Works of Havana.

By Traveler.

The gas man visiting Havana finds that city so different in nearly every respect from the cities of the United States—although Cuba is less than 100 miles away—that he feels there must be equal differences of interest at the gas works, and looks forward to visiting there with considerable pleasure. In such feeling he is not disappointed. The process of conveying to the Spanish cabman the idea that you desire to be taken to "the gas works" you wisely leave to the interpreter; incidentally noting, however, that, as soon as cabby catches the idea, his face lightens up, like as the face of a U. S. hackman, with recognition of "the gas works."

Arriving, one duly notes the holder columns and retort house roof over the wall, only to find, upon entering, that while it is a gas works all right enough, it is not the works supplying the city with gas; for it is shut down. It seems that Havana, with most other cities of any size, has duly had its opposition company, and that the result in Spanish is not very different from the result in English—*i. e.*, the consolidation of interests and two stations for making gas and expense. The driver has put you down at the works, built away back in the beginning by English interests, in the way that so many companies have been started and operated by English capital in the Spanish speaking South American countries.

The works occupy a large tract of ground advantageously situated on the back bay, in the rear of the city, so to speak. About 20 years ago some United States interests concluded that they wanted a slice of the Havana business, with the result that the Compañia Hispano-Americana de Gas, Consolidada (in other words, the Spanish-American Company) was also formed and a works built on the other side of the same bay. The usual followed. Consolidation; the new people in control of the business, and the old works shut down.

The gas to day is all made at the "Spanish-American" station, the English works being used only for storing, after drawing the gas through a connecting main laid under the bay. Excepting for the large electric plant (there located by the same lighting interests), the property is in a good state of decay. Holder tanks broken by an earthquake have never been repaired. Its English construction is evident throughout; most of the machinery looks like that in the pictures shown in English text books on gas. The vertical seams in the side sheets of the holders do not break joints, but are continuous. This is an earmark in the detail of English practice, which may also be noted naturally in many Canadian gas works. Exposed yard pipes and open houses are the logical outcome of this country, in which the temperature never gets below 60°, yet they look strange to a man who has contended with 30° below zero.

An oddity on the premises was a pile of postage stamps in the yard, amounting to several cart loads in quantity; in Cuba the government gets out a new stamp issue every year, and asks the Gas Company to burn up the unused balance of the old.

On the dock one steps into a little private launch, for conveyance to the other works across the bay. The boat's name—the *Marquise de Balboa*—reminds one that though the works were English built the country is Spanish enough. This is still more forcibly impressed upon one when arriving at the other side. The old works are in the city. The new ones are in the country. One lands upon a rambling dock, and observes a gas works, half or three-quarters of a mile away, in the midst of fields, a railroad track connecting the two. At the dock is a hand car to which a venerable white mule is hitched; I think, the largest, biggest, tallest mule that I ever saw. Behind this mule one sits on the handcar and away one goes up the track to the gas works, the Cuban driver gesticulating and belaboring the mule, the cactus hedges and royal palms, the thatched huts and the whole surroundings making an environment delightfully different from any gas works approach that one can find in the United States.

One is a bit disappointed, when reaching the works, to find that it is only a perfectly ordinary conventional plant after all, despite its attractive location. This, however, is but to be expected when one remembers that it was built by United States people. As a matter of fact it was made in Baltimore, and erected in its entirety by Messrs. Bartlett, Hayward & Co. The plant is made up of nine Lowe water gas generators, the usual scrubbers and condensers, purifiers (in an open building), meters and old holders as usual, and a three-lift new holder in a steel tank.

From the top of this holder the writer had one of the finest views that he ever had the pleasure of beholding. At one's feet was the land-locked harbor of Havana and the blue straits of Florida, picturesque to a degree, with the shipping and men of war of various nations or cities; across the bay was the Cabañas fortress and Moro Castle, flanked by minor forts protecting the city, located apparently in almost every direction. In front of one was also the city proper, a mass of flat top houses with tile and color, and cathedral towers spotted all over it, reminding one of Constantinople or Morocco; in the rear, rolling, open country, full of insurgents, stately royal palms, queer houses and aguardiente. The writer lingered on the top of that triple-lift holder; and, still remembering that magnificent view, will vouch for its being worth the while of any gas man to make the climb who gets to that works.

Below, Chinese coolies kept the grounds tidy, and did the dirtier work in the lime shed, etc. In one corner of the grounds was a very English locomotive, used to haul coal up the tramway from the dock whenever a schooner load arrived. In one corner of the gas house, and also of the office, was a stack of rifles—an uncommon article for gas making! The insurgents, however, are venturesome fellows; and while they dare not storm the Spanish stronghold—the city of Havana—they do dare harass its water provision, and may dare a raid on the gas works to cut off the light supply. As the plant is peculiarly out in the country, this would not be an impossible sortie on their part, and it is a daily point of conjecture, on the part of the Superintendent, as to whether he will or will not have, that day, use for the rifles, or have a ball from a field-piece go through the holder.

From what has been said above, it may be judged that the cost of gas in Havana is but little over the cost in the Southern States. This is true. Coal by schooner is cheap, and has no excessive haul. Oil, while higher than here, is yet within the range of some Southern States' prices. Lime is abundant. Labor is distinctly cheap.

It would appear that, on a selling price of somewhere around $4 per 1,000, and in a city of 400,000 population, the margin of profit would be quite satisfactory. The writer was assured, however, that most of the profit was given up in marvelously many and ingenious taxes, sinful waste and free gas, "leakage" in management and "expense," in long unpaid city contracts, and with the notoriously avaricious Spanish city and government officials.

Gas Manufacture and Appliances.

In the XXXIV. chapter of the series of articles contributed by Mr. Henry O'Connor, A.M.I.C.E., to the *Gas World* (London), the author writes on the matter of the distribution of gas. Having declared that the distribution of gas has not received that amount of study and attention in England which its importance demands, Mr. O'Connor goes on to say:

This is principally on account of the fact that the districts to be supplied have been invariably, in the first instance, of only very small area, and have afterwards spread on many sides. Again, in large towns the districts have possibly been at one time supplied by several separate and distinct companies, each having their own works, and each forming a source of supply. When, however, these companies are amalgamated, as is usually the case in course of time, the old mains have to be brought into use as far as can be done, and consequently correct systems of distribution are not adopted.

System of Mains.—Perhaps the very best plan that could be adopted is one suggested to the writer by the most eminent of distributing engineers, in which the trunk main, after passing completely round the district, returned finally to the works, where the pressure might be most accurately recorded. Here, then, would be the chance of at once checking or increasing the pressure in the district, as the intimation of its necessity would be indicated at the source of supply. All by-supplies would be taken from this trunk main, and, of course, would be proportioned to the probable consumption. It is the difficulty of gauging the probable consumption in a growing district which leads to so much trouble with the distributing mains. Mains which, when laid, have been of ample size for twice or thrice the consumption expected for some years have in less than that time proved inadequate, and fresh mains have had to be laid down of larger capacity. This, despite the cheapness of cast iron pipes at the present day, as compared to twenty years ago, is a very expensive matter, as many of the pipes to be taken up will have to be cut through in order to get them out, and much labor has to be expended, not only for the trenches and re making of the road surface, but also in the reconnection of the services to the various houses and street lamps. This latter, however, is not altogether labor in vain, as in most places where new mains are substituted for old, and services are thus laid bare, it is found that the latter are so eaten away as to be likely, ere long, if they have not already commenced, to leak to a considerable extent.

Connecting Services.—There is little doubt that this connection of the services to the mains is one of the greatest causes of leakage. When a leak is noticed it is usually found to proceed from the rotting away of the wrought iron pipe close to its jointing to the cast iron main. In many cases this is attributable to the method of connecting, which, in former years, was to drill a hole in the side of the main, or even to chip a hole with a cape chisel. Although this latter method is likely to be at once condemned by any really practical man, the writer has found it mentioned as the usual one in a book written for gasfitters, and re-issued only recently. This fixing of the pipe at the side of the main is liable to cause, not only damage to the service pipe, but also may be the ultimate cause of breaking the main itself, if any great weight should come upon the service pipe only and cause it to sink in the ground. Service pipes should be always fixed with a bend screwed into a drilled hole on the top of the main, and the horizontal service pipe screwed into the bend. Then the worst that could happen would be the pushing of the bend deeper into the hole, if the strain were sufficient to strip the thread on pipe or main.

For drilling mains there are many elaborate pieces of mechanism to be had, by means of which little or no gas is lost, but in most cases simple tools are preferred, owing to the ease of carriage from place to place, and the rapidity with which they can be brought into use. Ordinarily the ratchet brace, with a flat drill, is used with a bent hook, which is something like a letter ∩, with hooks to surround the pipe at the end of each of the legs. This forms the standard for the ratchet brace to work against. The only objection to the system is that when the hole is nearly through gas can escape; but this can be largely prevented by filling up the space around the drill with a lump of clay or a piece of oily waste. This escape of gas, however, is likely to cause asphyxiation to men working in a small hole, if there be no wind about. The antidote to be used if any one is overcome by the fumes of gas is milk, which should be given immediately.

Main Laying.—This, however, is perhaps getting to the end before the commencement, and it will be well to hark back to the the first part of distribution—namely, main laying. Trenches must be first dug along the line where the main is to be laid, preferably at the side of the road, and not under the pavement, as the last is generally more expensive to replace if it should be required to open up the main for any purpose. It should be laid at the side of the road so as to avoid having the heavier traffic passing continually over it. Steam rollers have increased the leakage very considerably, and at one time gas officials tried to make the users liable for damage by their use, but it was shown that if the mains were laid at a proper depth no damage would occur, and that the use of steam rollers was a necessity, so that no redress is now possible. The trench requires to be wider than the main, to allow the men to work in it, and, of course, must be made wider the greater the depth. It may be here mentioned that the deeper the main the better it will be for the supply of gas; but an increased cost will have to be faced when services have to be connected or the main examined. In any case no main should be less than 2 feet from the surface of the ground, not only on account of the possibility of breakage, but also because the earth at a lower depth will be more porous, and will the easier deteriorate the pipe, and at the same time the alteration in temperature of the pipe when it is near the surface is considerably more than when it is deep down. Such alteration of temperature causes condensation of the moisture in the gas, and with it a deposition of naphthaline, which in time may be so great as to cause a stoppage of the pipe.

Mains are always laid on a slope, no matter whether the surface of the ground is level or not. This is done for the purpose of running the condensation towards the lower points, where boxes are inserted to collect the moisture, and from which the same can be pumped. These boxes are called siphons or traps. In a level road the main will be at times, say, 2 feet from the surface, and from 4 to 5 feet deep at others, rising and falling at a minimum rate of 1 inch in every 20 yards, so that if the pipe is carried to 4 feet deep at the lowest point the siphons would be some 900 yards apart; but it will be found to be better to keep the ordinary slope of the pipes greater than this, and to bring the siphons closer together. These siphons consist usually of a round box with a socket on either side to connect the mains to them. Through the top is carried a ¾-inch wrought iron pipe with a cap on the top, and the lower end carried nearly to the bottom of the box. When the man comes to clear the siphon he removes the cap, fixes a small hand pump on to

this ¼-inch pipe, and pumps until the gas blows up through the pipe. He then removes the pump, and refixes the cap. A cast iron box with lid serves to protect the cap and pipe from damage by the traffic.

Jointing.—When digging the trench, a wider and deeper space must be left wherever the sockets come, as men have to work around the pipe in jointing. This jointing, in the case of ordinary socket and spigot joints, consists of first sending the pipe home into the socket, then passing several strands of tarred yarn around the pipe and caulking them home into the socket with a special caulking tool. This should be thoroughly done, or much lead will be wasted, as it is the yarn which prevents the lead running into the inside of the main. The yarn caulked in, a plaited rope of yarn is made, and coated thoroughly all round with soft puddle clay. This rope is then passed around the socket, and the clay carefully joined to the pipe and socket all round, except on the top, which is opened out to form a cup or gate where the lead is to be poured in. It can be easily understood that this clay ring must be made tight, or the molten lead will find its way out, and much lead will be required before a full joint can be made. The lead is heated in an iron pot something like a gipsy kettle, hung over a coke fire in what is termed a chauffer, care being taken that the lead is not heated up too long before it is required, or it will be impoverished. A ladle is used for carrying the lead from the chauffer to the pipe joint. The usual plan is to skim the surface of the lead to remove the scum, and then to fill the ladle with rather more lead than will fill the socket. Where a large joint is to be run one ladle will sometimes be insufficient; another should therefore be ready, and warmed, so that when the lead in the first is getting low the second can be brought. To prevent any stoppage in the flow the lead should be poured from the second into the first ladle, and thence, continuously, into the joint. As soon as the socket and the gate are filled with lead, and that in the gate is found to have set, the clay rope is removed and the clay upon it reworked for the next joint. The lead in the joint just run is then caulked with a chisel with a blunt end about the width of the space between the pipe and the socket, and is well hammered in and set up, the lead about the gate being cut off first. If too much lead is allowed outside the socket when running, and then caulked into the joint, it may have the effect of splitting the socket, so the clay ring should be kept close up to the socket before running. For small pipe joints 1 pound lead to the inch of diameter is usually required for each joint, but above 6 inches this is not sufficient, as it increases in proportion until, with a 24 inch main, the joint will require 2 pounds per inch, or 48 pounds lead for each joint.

Of more recent date is the turned and bored pipe. These joints are certainly more easily laid, as the socket is bored out, slightly taper, and the spigot end is turned to the same taper, so that all that has to be done is to paint over the turned surfaces and push the spigot right home, knocking it in, if necessary, with a wooden mallet. These pipes, however, do not lend themselves to going round curves, as very little variation is possible in the position of the spigot in the socket, whereas with the ordinary lead joint a fairly sharp curve can be run round with ordinary straight pipes laid with a little larger quantity of lead in the socket on the outside to that on the inside of the curve. It might be mentioned, also, that if any subsidence is at all likely, the turned and bored pipes will not give at all, but will break, while those with lead joints will only crush the lead and not cause much if any leakage of gas. If the pipes or yarn be wet, a little tallow or oil in the gate when running will prevent the lead blowing up and spurting out, as would be the case in the ordinary way, owing to the formation steam and the closing of all outlet for it.

Weight and Capacity of Pipes.—The smallest size of cast iron main pipe is now usually 3 inches diameter inside, although they are made as small as 1 inch diameter, but are not to be recommended. Smaller than 3 inches, they are usually 6 feet long; from 3 inches to 10 inches, 9 feet long; and above that, 12 feet long. The average weights per pipe are given in the following table, which include one socket:

	Lbs. Each.		Lbs. Each.
2 inches inside diam.....	50	9 inches inside diam.....	448
3 " "	120	10 " "	504
4 " "	175	12 " "	963
5 " "	224	14 " "	1,131
6 " "	280	15 " "	1,211
7 " "	336	18 " "	1,624
8 " "	392	20 " "	1,800

24 inch diameter, 2,548 lbs. each.

These weights, of course, vary considerably according to the thickness of the metal. The pipes should be cast on end, with the spigot end uppermost, so that any porous metal can be cut off. They should be of equal thickness all round. To test this they should each be laid on two metal rails. If they always lie steady when placed with any part of the circumference uppermost they may be considered sufficiently even in thickness; if, however, they always roll to one side, that will be the heavier portion. They should also be tested by water pressure to a head of at least 200 feet, or, in other words, to 90 pounds to the square inch, and, while under the pressure, tapped with a hammer from end to end. If the water is seen oozing from any cracks or flaws the pipes should be rejected.

Pipes with rough interior surfaces are liable to cause a reduction in the rate of delivery of any liquid passed through them, and also to cause a deposition of naphthaline when gas is going through; the pipes, therefore, should be smooth inside. If pipes are laid in clinkers or ashes the iron will gradually disappear from the pipe, leaving only the carbon, which can then be cut with an ordinary penknife. Clay forms an admirable soil for laying cast iron pipes in. Many engineers prefer to have their mains coated with a composition of a pitchy nature, and, perhaps, the best of them is composed of Burgundy pitch, oil, resin and gas tar, made up into a bath and kept heated at about 142° F. The pipes are laid in the bath until they have attained the same temperature, when they are removed and placed in such a position that any superfluous composition is run off.

As regards the carrying capacities of pipes of different diameters, the rule usually employed is one worked out by Dr. Pole, which is as follows:

Quantity of gas in cubic feet discharged per hour by any main =

$$1{,}350\ a^2 \sqrt{\frac{hd}{S\,L}}$$

where

h = pressure of gas in inches of water.
d = diameter of pipes in inches.
S = specific gravity of gas (air = 1).
L = length of pipes in yards.

Various other rules have been proposed, but the above is the one usually received, and tables were worked out by Mr. Barlow, many years ago, which show at a glance the quantity of gas which can be delivered through various sized pipes at various pressures and for different lengths. There was also published in the *Gas World* some time back a series of diagrams by Mr. Lewis T. Wright showing the pressure lost in passing gas through pipes of different diameters for different distances. These were excellent, and should be framed, and in every gas engineer's office for reference. The Norwalk Iron Company, of America, also made a series of calculations as to the relative carrying capacities of different sized pipes, by which it was shown that these did not coincide with their respective areas, a copy of which is here given.

Diameter of Pipes.	Comparative Capacities.	Comparative Areas.
24	1.00	1.00
12	0.17	0.25
10	0.10	0.175
8	0.06	0.111
7	0.04	0.085
6	0.03	0.0625
5	0.0139	0.0434
4	0.0102	0.0278
3	0.0045	0.0156
2	0.001485	0.0069
1½.....	0.000810	0.0079
1¼.....	0.000450	0.00272
1	0.000225	0.00173

The Heat of the Combustion of Acetylene.

Engineering notes that engineers quite commonly estimate the calorific value of a fuel from its chemical composition; and, speaking generally, the figures thus obtained are accurate within quite a small percentage. Exceptions, however, do occur, and acetylene is one of them. Its chemical composition is given by the formula C_2H_2, so that 13 pounds of the gas consist of 12 pounds of carbon and 1 pound of hydrogen. Now, 12 pounds of carbon burnt to carbonic acid gas will give 174,600 British thermal units, and 1 pound of hydrogen, burnt to H_2O, will liberate 61,560 British thermal units, making a total of 236,160 units. Actual experiment, however, shows the heat set free on the complete combustion of acetylene to be much greater, viz., 281,250 heat units, or nearly one-fifth more than that calculated from its chemical composition. Similarly, it is found that the actual heat of combustion

of cyanogen (C_2N_2) is nearly one third more than that calculated from its carbon content. The explanation of the discrepancy is, of course, to be found in the fact that a large quantity of energy is absorbed in the production of these compounds, which is liberated in the form of heat on burning them. It is this fact which renders compressed acetylene so dangerous an explosive; as, quite apart from any question of combustion, there is a large store of energy available for destructive purposes by the mere decomposition of the body into its elements. Some French experiments, indeed, showed the explosive energy of liquefied acetylene to be comparable to that of dynamite. It should, however, at the same time, be stated that at pressures not exceeding two atmospheres, it was found impossible to produce an explosive decomposition of the gas, which, under such conditions, is as safe as lighting gas. It is interesting to note that many food stuffs, such as starch and sugar, exhibit the same peculiarity as acetylene, their heat of combustion being greater than that estimated from their chemical composition.

ITEMS OF INTEREST FROM VARIOUS LOCALITIES.

THE JOURNAL for December 13th contained the statement that Mr. George Fullerton, Sr., had been appointed Superintendent of Distribution for the combined Buffalo (N. Y.) Companies. It was Mr. Fullerton, Jr., who received the appointment. Mr. George Fullerton, Sr., is Superintendent of the works of the Buffalo Mutual Gas Light Company.

MR. W. S. WONES has resigned the position of Assistant Superintendent to the Springfield (O.) Gas Company, in order to assume the Superintendency of the works of the Covington (Ky.) Gas Light Company.

A SPECIAL election was held in College Point, L. I., on December 17th, the matter submitted to the voters being whether the streets were to be lighted by means of arc lamps or by means of Welsbach incandescent gas lamps. The proposition to employ the Welsbachs was adopted by a fair majority, and the authorities and the Welsbach Street Lighting Company of America have closed a contract under which the latter will maintain 200 lights on public account for a period of five years.

A CORRESPONDENT, writing to the JOURNAL under date of December 23d, says: "Dear JOURNAL—Mr. Brackenridge's article, entitled, "X-Rays on the Gas Bill," which appeared in your issue for December 6th, is not only timely, but suggests as well some food for thought. What he says about the gas meter, the testing thereof, etc., is worthy of note; and some of his lines suggest the question why a meter, made by a meter manufacturing house of standing, experience and reputation, should not be considered correct for all purposes? Testing the meter, before putting it at work, to provide against possible errors arising from transportation, is no doubt a safe precaution; but when this is done why could not the public be brought to believe that a meter so tested is as correct as it is possible to get a meter? There seems to be a disposition on the part of some of the gas companies to repair and adjust their own meters. Would it not be better if the greater part of this work were left to the concerns engaged in the manufacture of meters; and would not the public have more confidence in the work completed under the latter condition than would be the case were it to become generally known that the gas company repairs and adjusts the meters? One of the many difficulties that confront gas companies is the lack of confidence that the public has, not only in the company as an entirety, but as to the meters which stand as the arbiters between the companies and the consumers; wherefore, every move in the direction of inspiring the consumer with greater confidence in either or both is well worth the making. Mr. Brackenridge has written a good paper, which is not only worth placing before every gas consumer, but which might be profitably studied by many a gas manager as well.—VERITAS."

MAYOR WEAVER, of Louisville, Ky., has appointed Mr. J. Henry Hoertz official gas inspector, vice Mr. John Breeden. We are sorry to chronicle the retirement of Mr. Breeden, who makes way for a successor, not because of inefficiency or otherwise, but simply because his politics differ from those which animate and control Mayor Weaver's public acts.

THE special committee appointed by the Board of Aldermen, of Birmingham, Ala., to "investigate" the Birmingham Gas Company, recently handed down the following findings:

"To the Honorable Mayor and Board of Aldermen: Your special committee appointed under the former resolutions of this Board to investigate charges made against the Birmingham Gas Company, beg leave to report as follows:

"*Resolved*, that this committee report to the Board of Mayor and Aldermen that we find the Birmingham Gas Company has violated its contract in the following respects. First; it has charged private consumers more than the contract price for gas. Second; it has discriminated wrongfully in furnishing gas to consumers at different prices. Third; it has furnished gas to consumers that was not of standard grade, and not free from all impurities. Fourth; that in other respects said Company has not complied with its contract.

"*Resolved*, further, That the City Attorney be instructed to report to the Board of Mayor and Aldermen what steps should be taken, by said Board in order that the said contract be declared forfeited, null and void; and that the franchises, easements and rights under said contract be annulled and vacated; and by contract here, is meant all agreements from time to time heretofore entered into by the Birmingham Gas Company and its predecessors, and to make due reports to said Board."

MR. WALTON FORSTALL, formerly in charge of the Lockport (N. Y.) Gas and Electric Light Company, has been appointed Assistant Superintendent of Distribution in connection with the United Gas Improvement Company's control of the Philadelphia gas works.

AT a meeting of the Board of Health, San Francisco, Cal., held about a fortnight ago, the chemist of the Board (Prof. W. T. Wenzell) was instructed to analyze the gas supplied by the local companies, and to file the return of such analysis with the Board. The examinations are to be made at least once a month.

THE Central Gas Company, of Stockton, Cal., at its last annual meeting, named the following executive management: Directors, L. H. Lang, Hoyle Greenwood, A. Blossom, George Finkbohner, J. N. Wood, N. E. Carpenter and W. H. Woodbridge; President, L. H. Lang; Secretary, Hoyle Greenwood; Treasurer, Sidney Newell.

THE city authorities of Chehalis, Washington, have discontinued the electric lighting plant operated there for some time on public account.

THE Welsbach Street Lighting Company, of America, has been authorized to make a trial test of its lamps on the streets of New Britain, Conn., the local authorities having granted the necessary permission.

THE proprietors of the Consumers Gas Company, of Wilkes-Barre, Pa., have called a special meeting, to be held February 28, 1898, the object of the meeting being to consider a proposition for the increase of the Company's stock from $60,000 to $120,000. The new capital issue is to provide funds for contemplated plant betterments, which latter include an additional gasholder (200,000 cubic feet capacity) and several miles of mains.

THE Consolidated Gas Company, of New York, is distributing a sensibly compiled and neatly printed pamphlet on "The Comfort of Heating by Gas." The chapters of the pamphlet treat in commonsense fashion of how living rooms may be heated, how laundries may be made habitable, and kitchens as well, with a hint as to how the temperatures in conservatories may be safely and simply regulated, all by means of gas. Whoever arranged the pamphlet did the work well.

SUPERINTENDENT HENRY S. WHIPPLE, of the Rockford (American) Gas Light and Coke Company, of Rockford, Ills., is to be credited with having devsied a showcard advertisement that must be seen by every resident of that city who uses its streets after nightfall. Close by the Company's gasholder, and at a height of perhaps 30 feet from the ground level, he has rigged a sign, the dimension of which is 7½ feet in width by 16 feet in height, the sign being made of cloth stretched over a frame, the back of which is of wood. The cloth bears in large letters, suitably displayed, the inscription "Use Welsbach Gas Light." Behind each of the letters is a 3-foot gas burner, and when the burners are lighted the inscription can be easily read at a distance of 1,200 feet. The location of the sign is perhaps 600 feet from the main street of Rockford. Another illuminated sign on the same order is rigged on the roof of the gas works. This sign bears the inscription, "Use Gas for Light, Heat, Power."

AT a recent meeting of the Board of Trustees, Port Richmond, Staten Island, John J. Manning, H. Butler and others asked for a franchise permitting them to lay gas mains underneath the roadways of Port Richmond. They agree to furnish gas at a price not to exceed $1 per

1,000 cubic feet. The corporate name of the concern is The American Illuminating Company.

THE Welsbach Street Lighting Company, of America, has recently made several notable installations of its lamps on public account in this city. Prominent among these are: The specimen at Broadway and 23d street, which consists of a cluster of 8 improved Manhattan lamps, fitted with single Welsbach lights; at Long Acre Square, two handsome iron columns support a reflector and a cluster of 8 improved Manhattan lamps, each lamp carrying double Welsbach lights; Park avenue, for 50 blocks of its length, is lighted by means of single Welsbach lights, set in the improved Manhattan lanterns. These practical illustrations of what may be accomplished in the direction indicated are well worth the inspection of any of the fraternity who, through accident or design, "find themselves in New York."

THE Minneapolis (Minn.) *Tribune*, of recent date, contains the following advertisement, which is given for what it is worth: "GRAND FORKS, N. D., December 22.—W. S. Russell, of this city, who was recently appointed receiver of the Dual City Gas Company, of Grand Forks, as the result of an action commenced against it by the Minnesota Loan and Trust Company, took possession Saturday. In 1893 the Gas Company, in order to secure the payment of $50,000 bonds, executed a trust deed in favor of the Trust Company. Suit has been commenced to foreclose this deed, and, in consequence, the appointment of the receiver has been made. The Gas Company was organized about three years ago, with a capital stock of $50,000, and during that time has lost about $125,000, with scarcely anything to show for it. The total value of the plant, it is said, is scarcely sufficient to pay several years' unpaid taxes, mechanics' liens, cost of the receiver, and the foreclosure. If the bondholders realize anything, it will not be over 5 per cent. on the face value of the bonds."

THE Lighting Committee of the Board of Public Works, Newark, N. J., has named the 11th inst. as the date on which the application of the projectors of the Peoples Gas Company for the right to supply gas in that city will be heard.

AT the annual meeting of the New Haven (Conn.) Gas Light Company, which will be held to-day, it is not at all improbable that important plant extensions will be discussed. The main thing in this direction seems to hinge on the need of additional storage facilities.

THE franchise of the Binghamton (N. Y.) Gas and Electric Company has been renewed. It is practically the same as the former one.

SUPERINTENDENT WHIPPLE, of the Rockford (Ills.) Gas Light and Coke Company, reports the sale in that city of 3,600 Welsbach lamps, since March 1, 1896.

THE Philadelphia *Ledger* tells the following tale: "Among the many who have lost a good thing by the transfer of the Philadelphia gas works to the United Gas Improvement Company, is Adolph Luhman, who has been living rent free in a three-story brick building, at 711 South Second street, for a considerable time—just how long seems not to be ascertainable. The facts have been developed by the taking of the inventory, incident to the transfer of the gas works to the leasing Company. The property, which is assessed on the books of the city as belonging to the Southwark and Moyamensing Gas Company, is valued at $7,000, and marked exempt on the tax rolls. It is on the west side of Second street, below Bainbridge, and was for some years used as a gas office under the Gas Trust, which bought out the Southwark and Moyamensing Company and with it the house in question. Luhman says that he paid rent regularly to Cashier White at the office of the Gas Trust, until the affairs of the latter passed into the control of the Bureau of Public Works, since which time, finding nobody to pay it to or demanding it he just let things go along. It is said he paid $45 a month, using the front part of the first floor as a cigar store, the back part as a barber shop and the rest of it as a dwelling." Mr. Luhman no longer occupies the premises.

ACCORDING to recent advices (dated December 21), the Board of Supervisors of San Francisco is considering the adoption of the following ordinance—at this distance the measure seems to be somewhat mouldy:

Whereas, Statistics of deaths occurring in this city and county show that an abnormally large proportion is due to asphyxiation or gas poisoning, and scientific investigation has shown that most of said deaths have resulted from the presence of carbonic oxide, technically carbon monoxide, in illuminating gas inhaled by the deceased, and further that the use of gas containing such substance is detrimental to the health of all citizens using the same for illuminating and other purposes, now therefore,

The people of the city and county of San Francisco do ordain as follows:

Section 1. It is hereby declared to be unlawful for any person, firm or corporation to manufacture for public use in this city and county, or to furnish to any person, for use by such person for illuminating or any other purpose whatsoever, any gas containing more than 5 per cent. of carbonic oxide, technically known as carbon monoxide.

Sec. 2. Any person, firm or corporation violating any of the provisions of this ordinance shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be punished by a fine not exceeding $500, or by imprisonment in the County Jail of the city and county of San Francisco not exceeding three months, or by both such fine and imprisonment.

Sec. 3. This ordinance shall take effect from and after its passage.

Locomotive Sparks for Fuel in Electric Power Stations.

By MR. E. C. BOYNTON, M.E., in *American Engineer*.

A prominent English railway official, while watching the burning of sparks at one of the power stations of the New York, New Haven & Hartford Railroad, remarked: "You tell me that this stuff has been already burned in your locomotives, and you are again burning it; now, pray tell me who burns it after you get through with it?"

The fact that the road referred to is using sparks as fuel, to generate electric power, has been mentioned in a general way by several of the technical papers and the daily press, but it will doubtless be of interest to many to know the details of the practice.

Many attempts have been made in the past to burn sparks, but with indifferent success, and vast quantities are daily going to waste. The exact chemical composition of sparks is not now known, though they are believed to be almost wholly carbon. They are so fine that they lie on the grate bars in a compact mass, and it is impossible to burn them by means of natural draft. A forced draft must be used, and it must be powerful enough to force the air up through the mass, and keep it in a more or less distributed condition. In practice this is clearly seen on looking through the open furnace door, when the whole top of the fire is seen in violent motion, the burning sparks jumping up and falling back in a continual shower.

The sparks are fed into the furnace exactly as they come from the extension front of the locomotives, not mixed with anything else. Experience has proved that it is not best to mix them with coal, as it greatly increases the difficulty of firing. They make an exceedingly hot fire, which, however, must be cleaned at intervals of three or four hours. This is necessary because the thickness of the fire increases rapidly, due to the great quantity of fuel fed into the furnace and the layer of ashes and clinker which accumulates on the grate must be removed. One furnace is cleaned at a time, and with the aid of the blower, the fire can be brought up to the required temperature in a remarkably short time. This is a great advantage, as it enables a fireman to carry an even steam pressure all through the process of cleaning. The extremely fluctuating load due to electric railway work makes the firing much more difficult than it is under ordinary stationary boiler conditions, and in order to produce an even steam line on a recording gauge, a fireman must learn to fire sparks, no matter how good a coal fireman he may be. The weight of sparks required for the evaporation of a given weight of water, as taken from a number of tests, may be said to be about double that of coal.

Several important departures from ordinary boiler practice have been found necessary to insure success in burning sparks, the first of which is in the boiler setting. The boilers used by this company are of the horizontal flue type, 72 inches in diameter and 19 feet long, and contain 130 3-inch tubes. Extending across and resting on top of the brick settings, at right angles to the boilers, are two pairs of heavy channel irons. From these, four heavy iron rods extend down to the sides of each boiler, two on each side near the ends of the boiler. These rods hook into lugs riveted on the sides of the boiler, at the center line. The boilers are thus suspended from four points, and all movement due to expansion or contraction is provided for in this manner.

A so-called "exploded idea" is also brought into successful use in placing the boiler so that the bottom of the shell is 48 inches above the grate bars, while the top of the bridge wall is only 18 inches above them. As a result of this, a very large combustion chamber is secured, the purpose or effect of which is to allow all the gases of combustion to become thoroughly ignited before entering the tubes. That this is of great advantage is shown by the very low temperature of the gases in

(*Continued on page* 15.)

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(*Continued from page* 14.)

the smoke flue after leaving the boilers. This temperature averages about 35° above that of the steam. The furnace is 6 feet wide and 7 feet long, making 42 square feet of grate surface. For convenience in cleaning fires, about 2 feet of the grate, nearest the bridge wall, is arranged to turn over and dump into the ashpit, by means of levers. The type of grate bar used is the well known "herring bone," with openings about ⅛ inch wide.

One of the most interesting details is the peculiar forced draft, because of its bearing on the burning of sparks. This part of the equipment consists of a cast iron cylinder or pipe about 9 inches in diameter and 2 feet long, bell mouthed at one end. This extends through the boiler front into the ashpit, either between the ashpit doors or through one of the doors. The bell mouth projects outward and in it is a hollow brass ring, 7 inches in diameter and nearly elliptical in cross section. On the inner edge of this ring are 20 small holes $\frac{1}{16}$ inch in diameter. There is a steam connection to this ring, and when steam is turned on the result is a large number of fine steam jets blowing through the pipe into the ashpit, and drawing with them a large quantity of air through the bell mouthed opening. The air is considerably heated by the steam after it enters the ashpit, and the sparks get what they require for perfect combustion—oxygen and hydrogen to combine with the carbon they contain. While the boilers are in service the main damper is set so as to be kept nearly closed by the automatic regulator when full pressure steam is on, and it opens very little when the pressure falls The object of this is to confine the gases and allow them to escape into the chimney very slowly.

A peculiarity about this method of burning sparks, and one that requires the constant attention of the fireman, especially when cleaning a fire, is that, if the steam pressure gets started downward, it is likely to continue going down so far that it is very difficult to restore it again without stopping the engines. This is due chiefly to the fact that the efficiency of the blower decreases rapidly with the falling steam pressure. With careful firing, however, this never occurs. The regular steam pressure carried with light loads is 100 pounds, but 125 pounds is carried at full load. The number of men required to fire a battery of boilers burning sparks is the same as would be required for coal. The weight of sparks consumed per electrical horse power hour averages 6 pounds at a cost of about 2 mills.

This cost refers only to freight charges for loading and hauling its sparks to power stations. The power consumption refers to an ordinary track with no steep grades or sharp curves. The speed is about 30 miles per hour when using the above power. An electric train seating about 200 persons and weighing 62 tons requires 36 pounds per train mile at a cost of 12 mills. The power developed by the motors is about $\frac{1}{100}$-horse power hour per ton mile.

The Market for Gas Securities.

The failure of the shareholders of the New York and East River Gas Company, at the adjourned meeting called for yesterday (Thursday), to ratify the merger agreement between that Company and the Equitable and New Amsterdam Companies, is responsible for a crop of rumors, some of which go to the extent of declaring that the consolidation scheme is off. That the differences existing between the Equitable and East River interests are serious is undoubted, but nevertheless it is also certain that the differences shall have to be settled, for the undertakers have gone too far in their arrangements to permit of any turning back. Nor do we believe that the courts will be appealed to. Naturally, the failure caused marked depression in values of city gas shares, Consolidated having sold down to 175, the opening to-day (Friday) having been made at 178½ to 179. Mr. Sage's specialties are 130 to 135 for the common, and 144 to 150 for the preferred. Equitable looks cheap at 260 asked, as does Mutual at 300. Brooklyn Union is certainly cheap at 118 to 119.

Peoples gas, of Chicago, is steady to strong, although some of the wiseacres are predicting lower prices in it. Bay State is absolutely lifeless, while Baltimore Consolidated is in better demand, at 52 to 53. Consumers, of Jersey City, is gradually hardening.

Gas Stocks.

Quotations by Cochran & Close, Brokers and Dealers in Gas Stocks.

35 WALL ST., NEW YORK CITY.

JANUARY 3.

☞ All communications will receive particular attention.
☞ The following quotations are based on the par value of $100 per share.

N. Y. City Companies.	*Capital.*	*Par.*	*Bid.*	*Asked.*
Consolidated	$36,220,000	100	178¼	179
Central	500,000	50		..
" Scrip	220,000	..	100	.
Equitable	4,000,000	100	..	260
Bonds, 6's	1,000,000	1,000	105	.
" 1st Con. 5's	2,300,000	1,000	114	.
Metropolitan Bonds	658,000	..	108	112
Mutual	3,500,000	100	.	300
" Bonds	1,500,000	1,000	100	102
Municipal Bonds	750,000	.	..	.
Northern	150,000	50	.	
" Bonds	150,000	1,000	..	98
New York and East River	5,000,000	100	70	71
Preferred	2,000,000	100	98	104
Bonds 1st 5's	3,500,000	1,000	112	113
" 1st Con. 5's	1,500,000	..	105	106¼
Richmond Co., S. I.	348,650	50	50	..
" Bonds	100,000	1,000	..	..
Standard	5,000,000	100	130	135
Preferred	5,000,000	100	144	150
Bonds, 1st Mortgage, 5's	1,500,000	1,000	114	115
Yonkers	200,650	50	130	.
Out-of-Town Companies.				
Brooklyn Union	15,000,000	100	118	119
" " Bonds (5's)	15 000,000	1,000	111¾	112
Bay State	50,000,000	50	4	4⅛
" Income Bonds	2,000,000	1,000	..	75
Boston United Gas Co.—				
1s Series S. F. Trust	7,000,000	1,000	96½	97
2d " " "	3,000,000	1,000	..	83
Buffalo Mutual	750,000	100	125	..
" Bonds	200,000	1,000	95	100
Central, San Francisco	2,000,000	..	95	..
Chicago Gas Company	25,000,000	100	97¼	97⅜
Guaranteed Gold Bonds	7,650,000	1,000	104	104¼
Columbus	1,000,000	.	.91	94
1st Mortgage	1,065,000	..	..	96
Consumers. Jersey City	2,000,000	100	77	..
" Bonds	600,000	1,000	102	105
Cincinnati G. & C. Co.	8,500,000	100	203	204
Consumers, Toronto	1,600,000	50	184½	187
Capital, Sacramento	500,000	50	..	35
Bonds (6's)	150,000	1,000	..	..
Consolidated, Baltimore	1,000,000	100	50	53
Mortgage, 6's	3,000,000	..	107	107½
Chesapeake, 1st 6's	1,000,000	..	..	..
Equitable, 1st 6's	910,000	..	..	..
Consolidated, 1st 5's	1,490,000	..	..	..
Consolidated G. & E. Co.'s,				
Little Falls, N.Y.	90,000	100	..	100
Bonds	75,000	..	..	100
Detroit	4,000,000		55	57
" Con. Bonds	4,312,000	..	97	97½
Equitable Gas & Fuel Co., Chicago, Bonds	2,000,000	1,000	..	101
Fort Wayne	2,000,000	..	81	93
" Bonds	2,000,000	..	93	95
Hartford	750,000	25	..	145
Indianapolis	2,000,000	..	118	125
" Bonds, 6's	2 650,000	..	107	109
Jersey City	750,000	20	180	..
Lafayette Gas Co., Ind.	1,000,000	100	86	88
Bonds	1,000,000	1,000	92	94
Louisville	2,370,000	50	..	..
Laclede, St. Louis	7,500,000	100	43¾	45
Preferred	2,500,000	100	92	93
Bonds	9,084,400	1,000	103	104
Montreal, Canada	2,000,000	100	200	.
Newark, N. J., Gas Co.	1,000,000	..	200	220
Bonds, 6's	4,000,000	..	126	130x
New Haven	1,000,000	25	225	..
Oakland, Cal.	2,000,000	..	53¼	54
" Bonds	750,000	..	..	..
Peoples G. L. & Coke Co., of Chicago	25,000,000	100	96¾	97
Peoples Gas Lt. & Coke Co., Chicago, 1st Mortgage	20,100,00	1,000	..	108
2d "	2,500,000	1,000	104	105
Peoples, Jersey City	500,000	50	..	175
Rochester Gas & Elec. Co.	2,150,000	50	..	..
Preferred	2,150,000	50	88	..
Consolidated 5's	2,000,000	..	87½	90
San Francisco, Cal.	10,000,000	100	94	94½
St. Paul Gas Light Co.	1,500,000	100	49	51
1st Mortgage 6's	650,000	..	84	87
Extension, 6's	600,000	..	..	..
General Mortgage, 5's	2,400,000	.	88	90
Syracuse, N. Y.	2,500,000	25	22	24
Bonds	1,000 000	..	94	97
Washington, D. C	2,000,000	20	250	..
Western, Milwaukee	4,000,000	100	83	85
Bonds, 5's	3,556,000	.	102	103
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DIVIDEND NOTICE.

OFFICE OF THE UNITED GAS IMPROVEMENT CO., 813 DREXEL BUILDING, PHILA., Dec. 23, 1897.

The Directors have this day declared a quarterly dividend of 2 per cent. (one dollar per share), payable on Jan. 15, 1898, to stockholders of record at the close of business Dec. 31, 1897. Checks will be mailed.

1178-2 EDWARD C. LEE, Treasurer.

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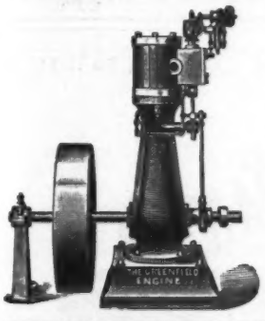

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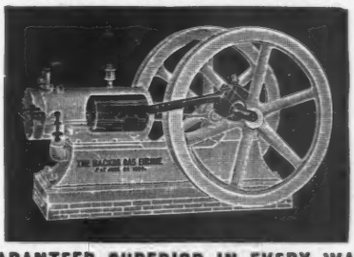

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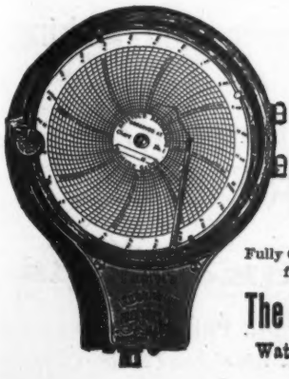

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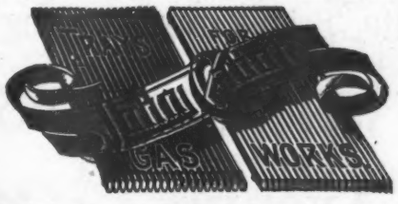

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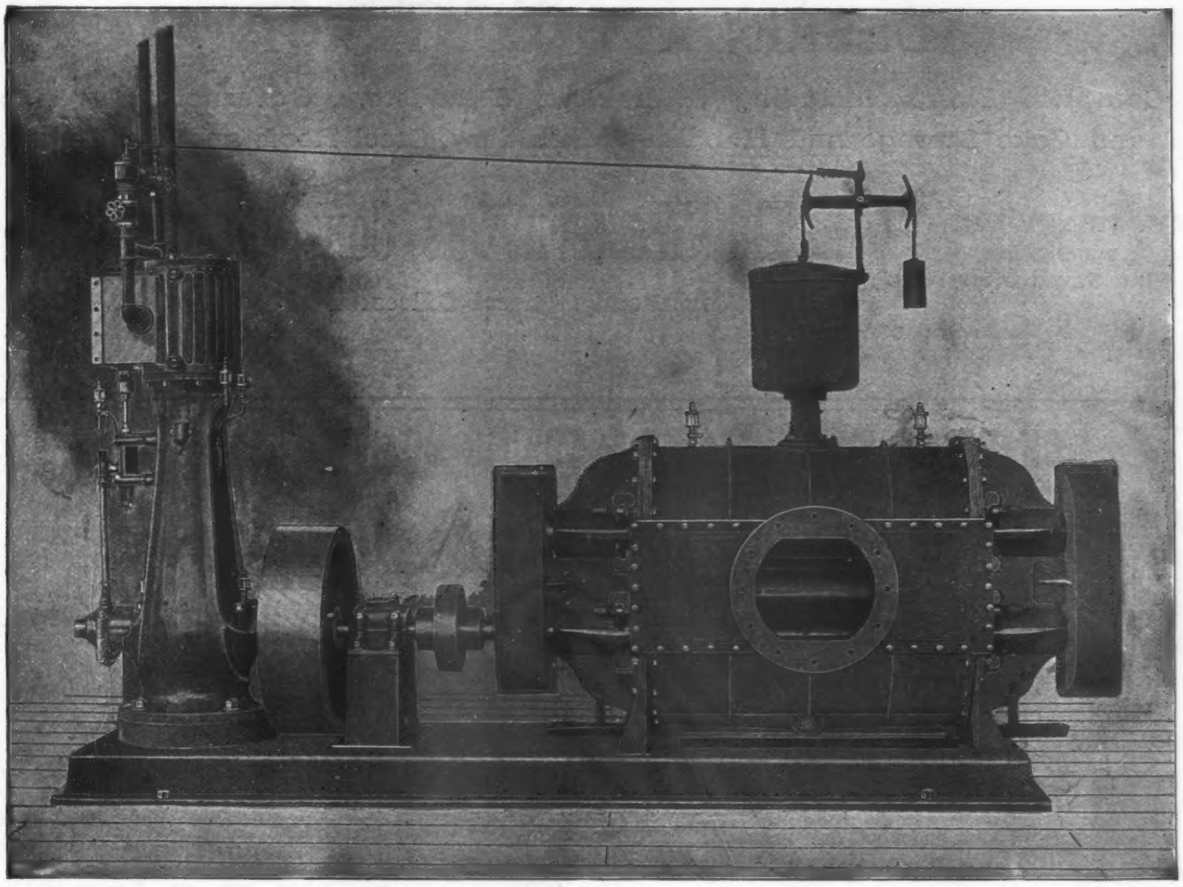

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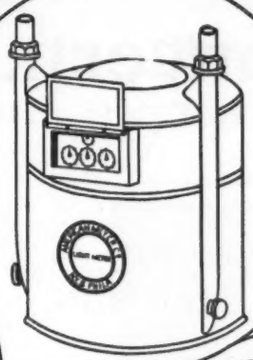

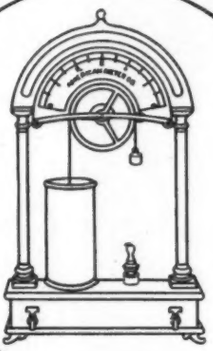

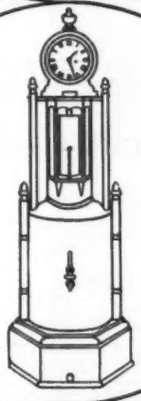

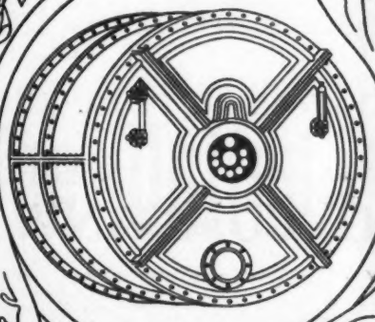

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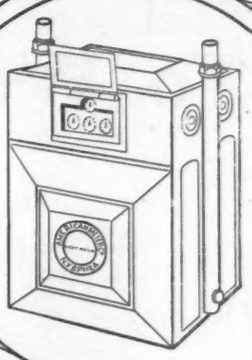
PUBLIC LIGHTING TABLE.

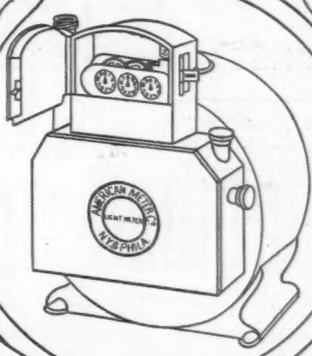
JANUARY, 1898.

Day of Week.	Table No. 1. Following the Moon. Date.	Light.	Extinguish.	Table No. 2. New York City. All Night Lighting. Light.	Extinguish.
				P.M.	A.M.
Sat.	1	1.50 AM	6.20 AM	4.30	6.30
Sun.	2	2.50	6.20	4.30	6.30
Mon.	3	3.40	6.20	4.30	6.30
Tue.	4	4.40	6.20	4.30	6.30
Wed.	5	5.30	6.20	4.30	6.30
Thu.	6	No L.	No L.	4.30	6.30
Fri.	7	No L. FM	No L.	4.30	6.30
Sat.	8	No L.	No L.	4.40	6.30
Sun.	9	5.30 PM	7.40 PM	4.40	6.30
Mon.	10	5.30	8.40	4.40	6.30
Tue.	11	5.30	9.50	4.40	6.30
Wed.	12	5.30	10.50	4.40	6.30
Thu.	13	5.30	12.00	4.40	6.30
Fri.	14	5.30	1.10 AM	4.40	6.30
Sat.	15	5.30 LQ	2.20	4.50	6.25
Sun.	16	5.30	3.30	4.50	6.25
Mon.	17	5.30	4.50	4.50	6.25
Tue.	18	5.30	6.20	4.50	6.25
Wed.	19	5.30	6.20	4.50	6.25
Thu.	20	5.30	6.20	4.50	6.25
Fri.	21	5.30 NM	6.20	4.50	6.25
Sat.	22	5.30	6.20	5.00	6.25
Sun.	23	5.40	6.10	5.00	6.25
Mon.	24	5.40	6.10	5.00	6.25
Tue.	25	5.40	6.10	5.00	6.25
Wed.	26	9.30	6.10	5.00	6.25
Thu.	27	10.30	6.10	5.00	6.25
Fri.	28	11.30	6.10	5.00	6.25
Sat.	29	12.40 AM FQ	6.10	5.05	6.15
Sun.	30	1.40	6.10	5.05	6.15
Mon.	31	2.40	6.10	5.05	6.15

TOTAL HOURS LIGHTING DURING 1898.

By Table No. 1.	Hrs. Min.	By Table No. 2.	Hrs. Min.
January	210.40	January	423.20
February	186.40	February	355.25
March	181.20	March	355.35
April	166.10	April	298.50
May	156.40	May	264.50
June	144.30	June	234.25
July	147.30	July	243.45
August	157.10	August	280.25
September	169.50	September	321.15
October	186.00	October	374.30
November	204.30	November	401.40
December	218.30	December	433.45
Total, yr.	2129.30	Total, yr.	3987.45





To Whom It May Concern.

WE have learned that the makers of the "Sunlight" lamp assert that there has been a decision in the English Courts which saves them and their customers from liability as infringers of the Welsbach patents.

We assure the public there is no decision of any Court, in England or elsewhere, that directly or indirectly warrants the statement or inference that the lamp sold by the Sunlight Incandescent Gas Lamp Company of America is not an infringement of the Welsbach Light as made under the American patents, of which the Welsbach Light Company is sole and exclusive owner.

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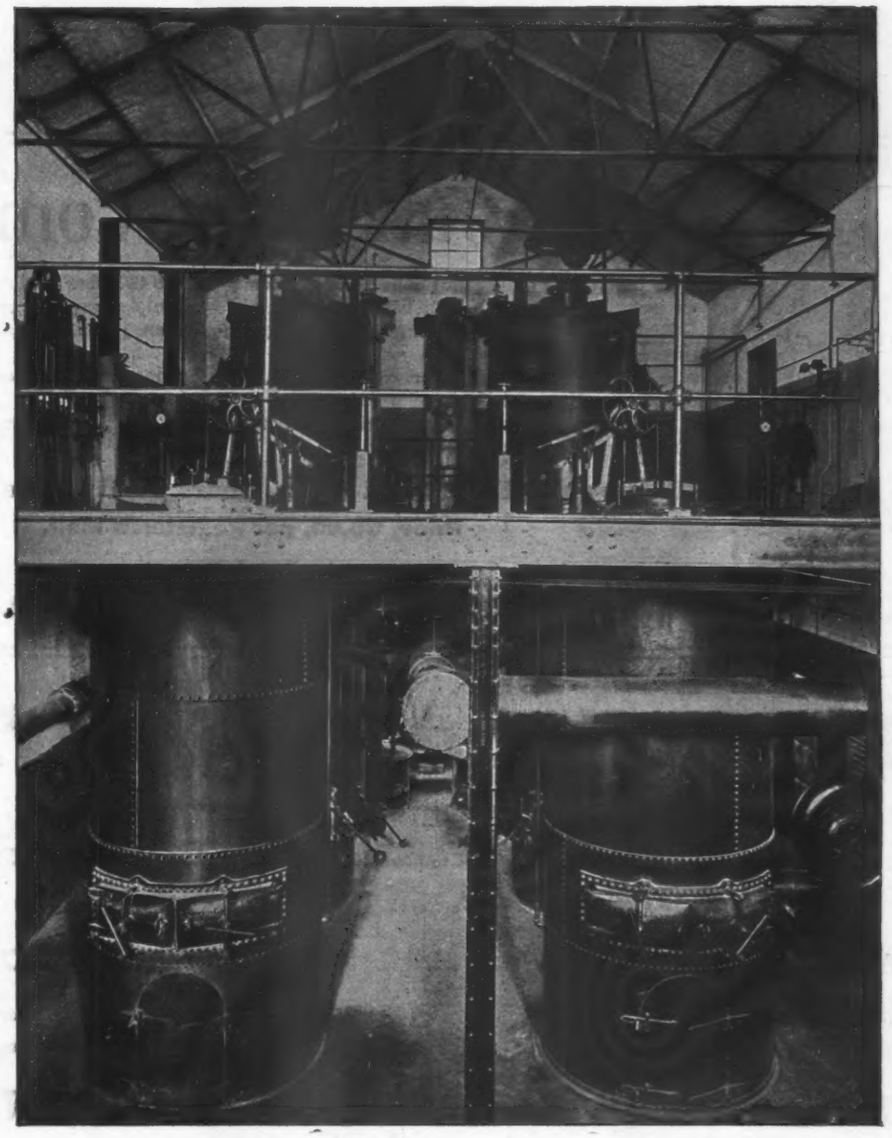
Number of Installations to Date, - - 240

Total Daily Capacity, 128,200,000 Cu. Ft.



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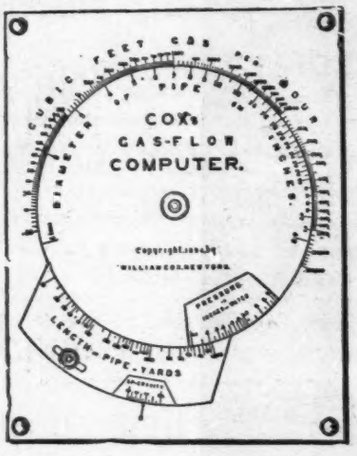

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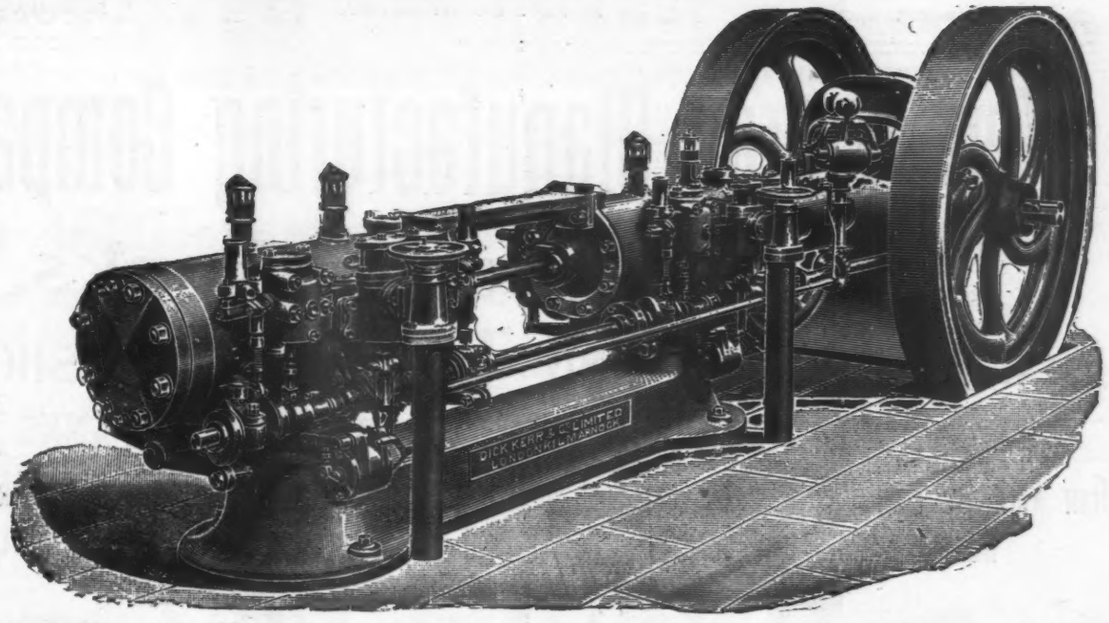

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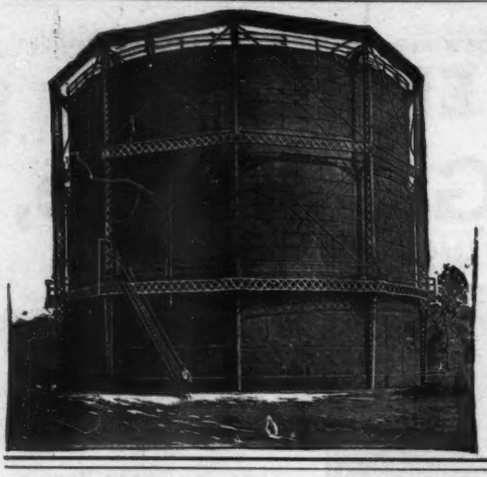

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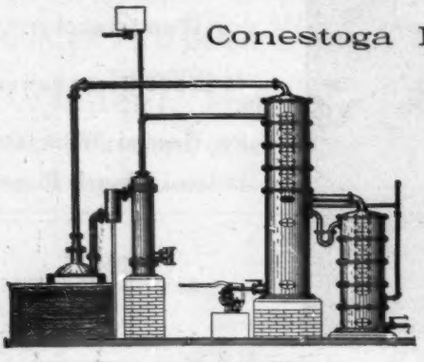

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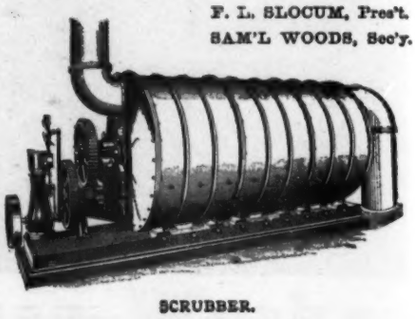

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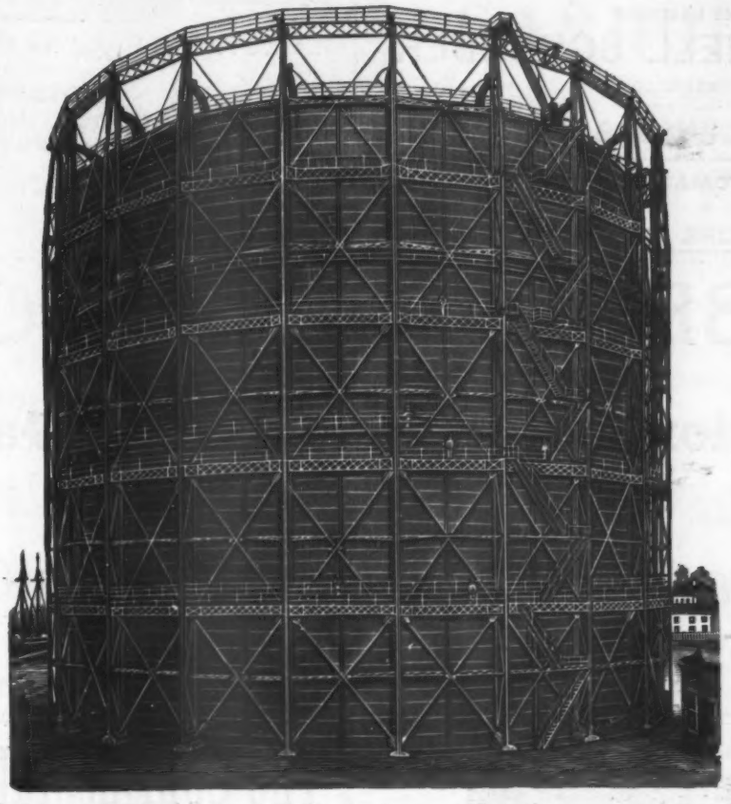

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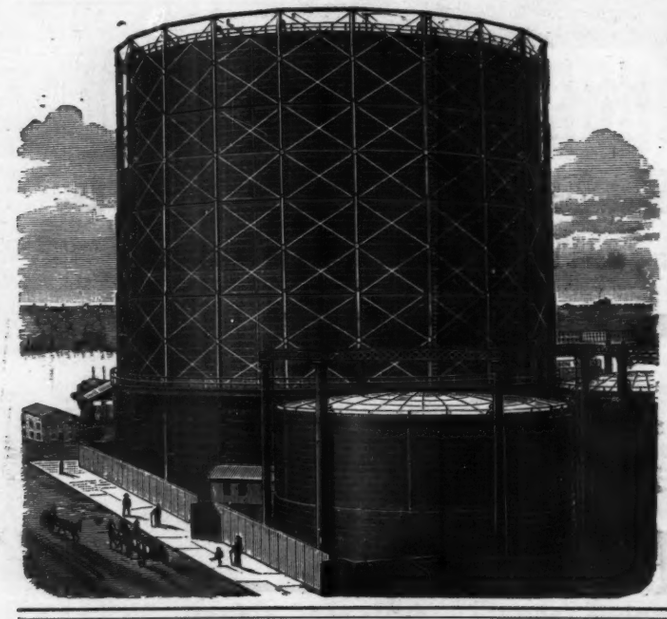

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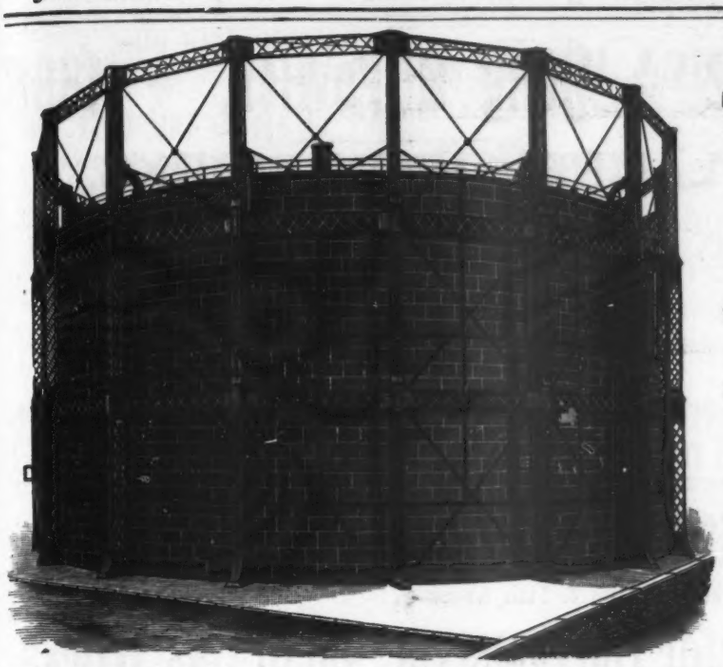

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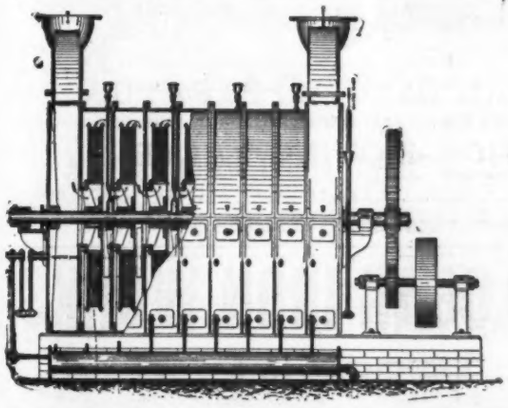

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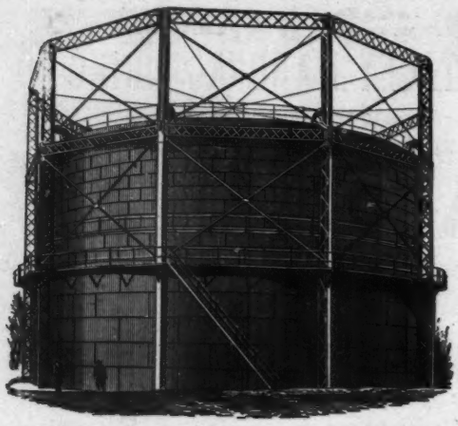

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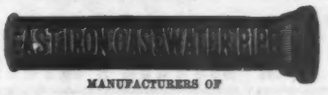
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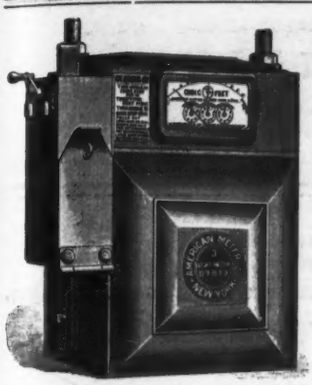

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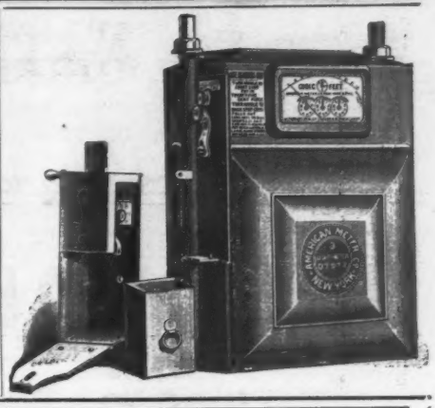

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For the Year 1896.

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For simplicity of construction and grace in design.
For general reliability.
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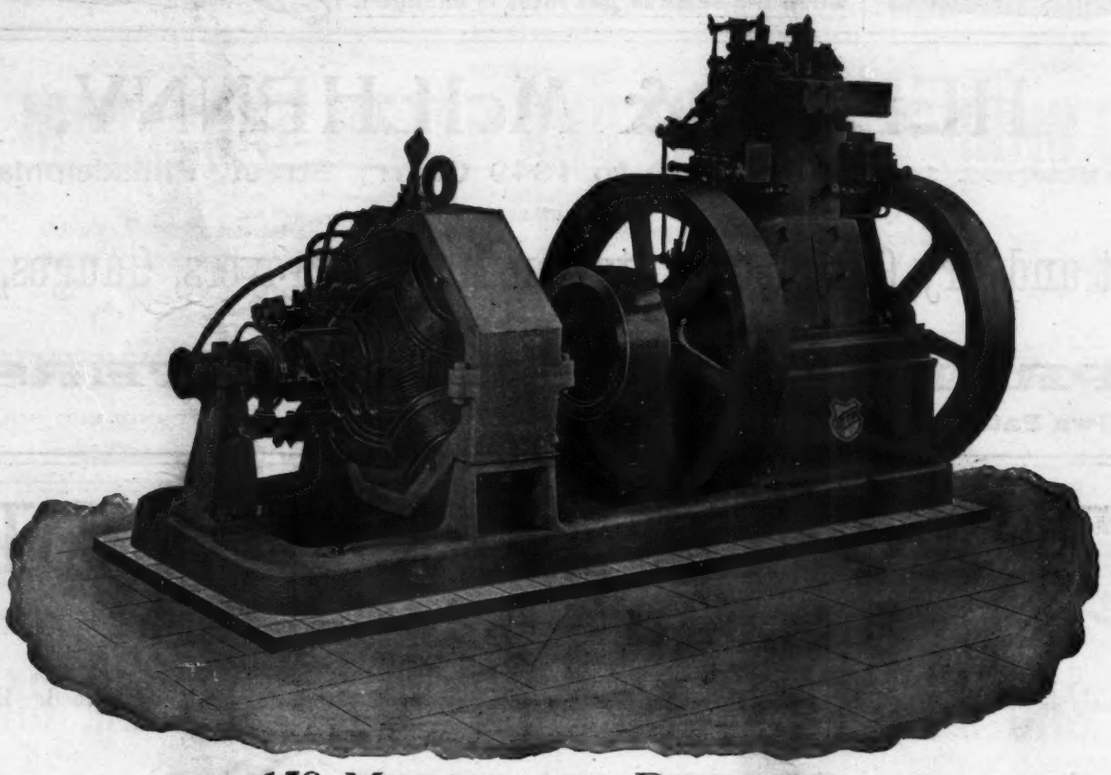

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